International Conference on Biomass Energy Systems

26-27 February 1996, New Delhi

Background Material

Organized by
Tata Energy Research Institute (TERI)
British Council Division, British High Commission

Biomass Energy - The UK Programme

by

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Biomass Energy Systems - Conference in New Delhi

ABSTRACT

Biomass Energy - The UK Programme.

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In the UK renewable energy is given financial government assistance in two ways These are the Non Fossil Fuel Obligation (NFFO) and the New and Renewable Energy Programme The NFFO is a premium price scheme for electricity from renewables designed to create a commercial market The New and Renewable Energy Programme, which is funded by the Department of Trade and Industry and managed by ETSU, is complementary and involves working with industry to develop the technologies and the industrial and market infrastructure

This paper will present a brief overview of these two measures with the emphasis on biomass The UK is supporting work on biomass energy in three broad areas; agricultural and forestry residues, energy crops and advanced conversion technologies The paper will describe some of the activities in these areas and go on to examine in more detail some of the newer developments in power generation from biomass

In the UK the advanced power generation technologies of pyrolysis and gasification are seen as essential if electricity from biomass is to become competitive with fossil fuel derived power These processes offer methods of power generation with higher efficiencies than combustion based steam cycles. These high efficiencies are achieved by first converting the solid biomass to liquid (pyrolysis) or gaseous (gasification) fuels then burning these intermediates in engines or gas turbines

The UK Programme and industry is particularly aware of the market for these technologies in the developing and newly industrialised economies where often a strong demand for electricity is coupled with a plentiful supply of low cost agricultural and forestry residues. Pyrolysis and gasification are particularly suited to rural areas as they can provide relatively small amounts of power efficiently. They are also capable of producing good quality process heat as a by-product which makes them attractive choices for co-generation in the agro-processing and sawmill industries.

Introduction

Electricity from biomass has the potential to become one of the largest contributors of renewable, sustainable energy in the UK (1) and many other parts of the European Union (2). It will not, however, achieve this potential unless the cost of electricity from biomass can be competitive with that from other sources. The use of high efficiency power generation cycles based on gasification and pyrolysis processes, combined with dedicated energy forestry, is one of the most promising ways of achieving this potential. The realisation of this has led to a number of recent policy initiatives in the UK , the most notable being the introduction of the Non Fossil Fuel Obligation for this technology area and an active industrial support Programme, the New and Renewable Energy Programme

This paper will describe the UK view on biomass energy and describe some of the policy and support measures that have been put in place to develop the technology

UK Government Policy

Government policy is,

> "to stimulate the development of new and renewable energy technologies where they have prospects of being economically attractive and environmentally acceptable in order to contribute to;
>
> - diversity, secure and sustainable energy supplies,
> - reduction in the emission of pollutants;
> - encouragement of internationally competitive renewables industries
>
> The coal review White Paper recorded the Government's intention to work towards a figure of 1500 MW of new renewable electricity generating capacity in the UK by the year 2000. The making of Non-Fossil Fuel Obligation Orders (NFFO) under the Electricity act 1989 is the Government's main instrument for pursuing the development of this capacity
>
> The purpose of these Orders is to create an initial market so that in the not too distant future the most promising renewables can compete without financial support. This requires that there is a steady convergence under successive Orders between the price paid under NFFO and the market price This will only be achieved if there is effective competition in the allocation of NFFO contracts "

The implication of UK policy is that biomass energy must be able to show a clear path by which it can become competitive with other fuels To achieve this we must attain two goals;

- a high efficiency conversion technology with a capital cost <£1100/kWhr
- biomass price less than £1.3/GJ.

The UK is pursuing these two goals by directing the NFFO scheme in this area exclusively to high efficiency technologies and at the same time implementing a research, development and deployment programme to address uncertainties.

The Non Fossil Fuel Obligation (NFFO)

The Non Fossil Fuel Obligation is, as stated above, the main policy instrument for achieving the UK's target of 1500MWe of renewable electricity capacity by year 2000 In brief, this is a premium price electricity scheme whereby the government obliges the electricity supply companies to buy a certain amount of electricity from generators using a range of renewable sources The actual price paid depends upon the renewable technology and is set by a competitive bidding procedure.

The New and Renewable Energy Programme

In addition to the market creation measures of the NFFO the UK also has a Market Enablement Programme, The New and Renewable Energy Programme, that concentrates on providing support for UK industry. In the Biomass area this support is concentrated on energy crop fuel supply chains, conversion processes and tools to evaluate and optimise complete biomass energy systems

Energy Crops are a Priority

The UK does not have a lot of conventional forestry. Less than 4% of the land area is covered by forest - less than any other European country Thus, if we are to have any substantial amount of energy from biomass it must come from dedicated crops For the UK the most suitable crop is arable coppice. This is a modern version of the very old practice of coppicing, or cutting some varieties of tree back close to the ground to force branching. The growth is then always at its most vigorous. Modern cultivation involves the planting of around 10 000 cuttings per hectare, cutting back after the first years growth and then taking a harvest of fuel by cutting back every third year Willow and poplar are used mostly although other species may be suitable in some areas Typically the wood is harvested with modified machines that were originally developed for use with maize and sugar cane.

The UK programme is supporting industry in a number of ways to promote the commercial application of arable coppice The guiding principle is to concentrate on those areas where there is a significant technical risk. Thus work is being carried out on;

- the effects of soil type and clone selection on crop performance;
- willow rust control
- biodiversity and other environmental impacts,
- storage and drying
- harvesting machine development and;
- transport logistics

This work has succeeded in identifying and addressing many uncertainties in the arable coppice fuel chain and has put the UK industry in the position of being able to supply to a number of planned power generation projects submitted as part of the NFFO

Most of the work carried out by the Programme in this area is published in reports available from the ETSU Enquiries Bureau

Advanced Conversion Technologies are Necessary

As stated above Government policy is to support the development of those technologies that have the potential to compete with fossil fuels within a reasonable length of time If biomass is to come into this category then it will be necessary not only to grow the fuel at low cost but also to convert it to electricity in a highly efficient manner

Conventional fossil power generation technology has always increased the conversion efficiencies by using more and complex steam cycles that require larger and larger plant sizes to be cost effective. Biomass cannot use this route as the size of the station is determined by the size of the fuel resource. In the UK this will rarely exceed 30MWe

The advanced conversion processes of pyrolysis and gasification higher efficiencies than combustion based steam cycles at the sizes appropriate to biomass. These high efficiencies are achieved by first converting the solid biomass to liquid (pyrolysis) or gaseous (gasification) fuels then burning these intermediates in engines or gas turbines. By doing this the heat is converted to power at a higher temperature than in the simple steam cycle giving the potential for thermodynamically more efficient processes

In the UK there are a number of possible markets that could develop It is feasible to build **larger scale plant** at a size of 25 to 30MWe in the more arable parts of the country but **medium scale plan** of 5 - 15 MWe may be more suitable in mixed farming areas There also seems to be a demand for **small scale heat and power** at a size of a hundred or less kilowatts. The new technology of **Flash Pyrolysis** is also attracting a great deal of attention from power plant developers in all of these markets because of its inherent flexibility.

The UK New and Renewable Programme is supporting industry in developing technologies for all of these market sectors. As with arable coppice development, the principle is to help industry to overcome technical risk by supporting research and development activities

Larger Scale Gasification Plant

Fluidised bed gasifiers operating at atmospheric pressure are probably the best option at this size. Electricity is most likely to be generated using a gas turbine combined cycle.

It is likely that, due to the economies of scale these larger plant will produce the most competitive power for grid connection In recognition of this the European Commission announced in 1993 that they would part fund the building of one or more demonstration projects using biomass gasification to produce power Fluidised bed reactors and gas turbine cycles were preferred and the fuel supply was to be short rotation coppice. One of these projects "Project ARBRE" is located in the UK and has been awarded a contract under the NFFO arrangements

The main participant of Project ARBRE is Yorkshire Water who are working with TPS from Sweden and other European companies. The main parameters of the of the project are as follows.

- 2000 hectares of willow and poplar short rotation coppice.
- Yields enhanced by sewage sludge application to the coppice
- TPS gasification technology.
- EGT Typhoon gas turbine in a combined cycle with exhaust firing.
- 8 MW exported power.
- Total project cost including the first year's operation is 36.4 MECU.
- 31% electrical efficiency
- Planting Spring 1996, first fire 1998

As Project ARBRE is very much in line with UK policy, the National Programme actively encouraged the project by funding pilot plant work and design studies The intention is to support the independent monitoring of both the power plant and its associated fuel supply

Medium Scale Gasification Plant

The most suitable unit in this size range is likely to be the fixed bed updraft gasifier which supplies a fuel gas to a reciprocating engine. This is a simple unit that gives the low capital cost essential for economic projects at this size. Efficiency will be moderate at 30 to 35% when compared to the larger gas turbine combined cycles (44%). This efficiency is still, however, substantially above that of comparable steam turbine plant. A further advantage of this type of plant is the high temperature heat rejected from the engine that can produce substantial quantities of steam or hot water. This feature makes it particularly attractive for CHP or the agro-processing industries.

The major area of technical uncertainty with this technology is the removal of the large quantities of tars from the gas produced from the fixed bed gasifier. If not removed these tars will accumulate in the engine inlets and valves, soon causing failure. Work is being supported by the NREP into removal processes, primarily catalytic cracking to lighter hydrocarbons. This work has been successful so far an we are hoping to see the first demonstration built under the NFFO arrangements in the near future.

The UK company Wellman has been supplying fixed bed gasifiers for coal for many years and should soon be in a position to deliver turnkey biomass power plant.

Small Scale Gasification

Currently the fixed bed downdraft gasifier coupled to an internal combustion engine is the only available option. This simple concept is derived from wartime applications in Germany and Sweden. The great advantage of these units is that the reactor destroys in situ the tars formed as the wood breaks down. Elimination of this tar is essential as it causes serious damage to the engine. Whilst this design is simple, the unit must be supplied with a dry, regularly sized wood feedstock if the tar elimination process is to be effective.

The simple design combined with mass produced engines give a generating set with a low capital cost. The conversion efficiency from biomass to electricity is around 20 - 25% with the added potential of extracting heat from the engine exhaust and jacket.

The NREP has carried out a number of studies in this area and supported demonstrations, with mixed success. As a result of these activities we have come to the conclusion that for a small scale wood gasification system to succeed economically there are a number of criteria that must be fulfilled.

- Substantial internal demand for both heat and electricity.
- Equipment cost below £800/kWe
- Low feedstock price
- Electrical efficiency over 20%
- Minimum operating labour
- Availability over 5 0 hours per year.

Experience from the Enniskillen College CHP project has shown that the equipment cost target is attainable but reaching high availabilities with a low manning level will be very difficult. This was underlined in a further study (3) carried out under the JOULE II Programme where availability was singled out as being of paramount importance for the economic operation of any power plant in this size class. It has to be said that the combination of low manning and high availability has proved very elusive with this technology and some further development or new thinking is most certainly needed.

Flash Pyrolysis

Pyrolysis breaks the biomass down into charcoal and hydrocarbons by indirect heating. A mixture of gas, liquid and solid products are produced but the proportion of each can be varied depending on the reaction conditions

In flash pyrolysis finely divided biomass (<3mm) is exposed to high temperatures for less than 1 second and then rapidly cooled. It is the high heating rate of the particle which ensures a low yield of charcoal with a mainly liquid product. Such flash pyrolysis liquids can be produced with yields of up to 75% by weight of the incoming biomass. For power generation the liquid product can be burned directly in engines

The greatest area of technical uncertainty seems to be the use of the pyrolysis liquids in engines. The liquids burn well in dual fuel diesel engines but are corrosive and difficult to ignite initially Residual charcoal in the liquid is also a problem. The NREP is supporting work with a UK engine supplier , Ormrod Diesels, to design and test a series of modifications to convert medium speed engines to pyrolysis liquids Initial results are encouraging and a commercial product should be available in two to three years time.

A liquid fuel has two great advantages in power generation in that it can be stored and transported cheaply. This opens up the possibility of separating the oil production from the power generation Thus a central oil facility could supply a number of engines placed at strategic points around a distribution network or locations where the rejected heat could be used. On a simpler level the availability of a stand alone plant could be improved by placing a buffer store between the power generation engine and the oil production so that a break down in one would not affect the other.

Possibilities Outside the UK

In many parts of the world the use of biomass to provide small amounts of power at several locations distributed over a wide area is an attractive alternative to installing or strengthening centralised grid systems This concept is particularly attractive in areas, such as India and Latin America, where an abundance of agricultural residues is combined with a strong growth in the demand for electricity All of the technologies described above would be suitable for use in situations such as this.

The New and Renewable Programme recently commissioned a survey of world wide prospects for sales of biomass gasification equipment. From that study it emerged that the use of sugar bagasse for power generation was by far the most important. Here the use of gasification technology could increase the amount of power exported from the average mill by a factor of three or four. Mills vary in size but most would have the capacity to generate between 5 and 30 MWe during the crushing season This size range suits the updraft and fluid bed gasifier technologies very well. A further interesting possibility is the use of pyrolysis to produce a liquid fuel which can then be stored for off season use

Pyrolysis systems have a further advantage for distributed systems in that the liquid fuel can be used as the energy carrier Thus the liquid can be produced and stored at the mill or factory using residues and then transferred at intervals to small engine generating sets in remote areas This would be particularly valuable for islands or remote areas where the existing network is weak and prone to instability - in these cases several small generators are much better than one centralised facility

Although the NREP has recently started to look at markets outside the UK for equipment it has become clear that these are very large and could provide a significant boost for the technologies and accelerate development

Evaluation and Optimisation of Biomass Energy Systems

ETSU has developed a computer model that allows all the costs of an integrated biomass energy system to be studied. This model is called RECAP and gives results that are vital for the steering of development activities in the energy crops field The following can be modelled,

- costs of biomass to energy systems,
- net margins and internal rates of return for the grower and power plant;
- optimum configurations under different scenarios,
- viability of new technologies;
- optimum harvesting, storage and drying strategies,
- risks to the grower and power plant,
- sensitivity analyses
- targeting of R and D

Future developments of this model will integrate geographical information systems that will allow the potential of energy cropping to be determined on a regional or national basis. Although at present set up for European conditions there is no reason why the model could not be used for tropical crops to evaluate, say, the integration of energy crops into sugar production to ensure continuity of fuel supply outside the crushing season

In Conclusion

The combination of market initiation measures such as the NFFO and support to industry through a research, development and demonstration programme is creating the basis of a strong biomass industry in the UK

Due to the circumstances in the UK this industry will concentrate on energy crops and advanced power generation technologies.

Many of the technologies being developed in the UK could become important providers of distributed power world-wide

Disclaimer

The views expressed in this paper are those of the author alone and do not necessarily represent those of either ETSU or the UK Department of Trade and Industry.

Country paper on biogas in Nepal

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COUNTRY PAPER ON
BIOGAS IN NEPAL

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COUNTRY PAPER ON BIOGAS IN NEPAL[1]

By Krishna M. Gautam[2]

1. COUNTRY BACKGROUND

Nepal is an agricultural country with more than 90 percent of the population engaged in agriculture and related activities With the reduction of forest cover in the fragile geology, problems of soil erosion, land slides and flood have become more common than in the past. Together with the growing population the pressure on the remaining forest and cultivated land is ever increasing.

The total energy demand of the country is estimated at about 252 million gigajoules and 95 percent of this is used in the domestic sector, mainly for cooking This bulk of energy demand is met by firewood (80 percent), agricultural residues (11 percent), dung cakes (9 percent), petroleum products (1 percent) and electricity (0 5 percent). Compared to 1980/81, the burning of agricultural waste and dung cakes have increased by 15 times in 1992. Substituting traditional household energy with some alternatives was of pressing need. Of all other sources of alternative energy tried out in the past, the biogas technology has proved to be the most preferred as economically viable, socially acceptable, technically feasible as well as sustainable and manageable in the context of Nepal.

2. BIOGAS

Methanization is a process in which a combustible gas commonly called biogas is produced by anaerobic decomposition of organic materials by the action of methanogenic bacteria. This gas is mainly composed of methane (50-60 percent) and carbon dioxide (30-40 percent) plus some hydrogen and traces of nitrogen, ammonia and hydrogen sulphide. The proportion of methane and other gases vary according to the nature of organic materials used. Theoretically, all biodegradable materials can be used to generate methane through anaerobic decomposition. However, in practice. mainly animal dung (especially that of cow and buffalo) is used as raw materials for feeding biodigesters in Nepal.

In Nepal, biogas is used mainly for domestic cooking and to some extent for lighting to replace firewood and kerosene The industrial application of biogas, for instance, to run dual fuel engines, refrigerator and to generate electricity has been made on a limited scale. Similarly, little work has been done on the production of biogas from biodegradable materials other than animal wastes, for example, agro-industrial and municipal wastes One of the pressing needs of the country is to promote the concept and practices (technology) of methane generation from agro-industrial and urban waste to abate pollution and to produce commercial viable bio-energy and organic fertilizers to enhance crop production

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[1] Paper presented at International Conference on Biomass Energy Systems organized by Tata Energy Research Institute (TERI), British Council Division and British High Commission. 26-27 February 1996

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3. BRIEF HISTORY OF BIOGAS DEVELOPMENT IN NEPAL

Technology

The first biogas plant in Nepal was introduced in 1955 by the late Father B. R. Saubolle out of a used oil drum at St. Xavier's School, Kathmandu. Till early seventies, the technology remained a subject of personal interest for some individuals and a few plants were constructed in Kathmandu merely out of personal curiosity.

The world energy crisis of 1973 created a global interest in developing alternative energy technologies. In Nepal, this caused the formation of an "Energy Research and Development Group (ERDG)" in 1975, under the Tribhuvan University. A "Biogas Development Committee" (BDC) was also formed as a part of ERDG. These initiatives taken by an academic institution were instrumental in drawing the interest of government authority to the relevance of biogas technology in the overall development context of Nepal.

The Ministry of Agriculture (MOA) observed the Fiscal Year (FY) 1975/76 as the "Agriculture Year". Biogas was included as a special program particularly for its relevance to controlling deforestation and preventing burning of cow dung which otherwise could be used as an organic fertilizer to improve soil fertility for increased crop production. Interest free loan was availed to families for the construction of biogas plants. These organized efforts led to the construction of the first 250 family size plants in 1975/76, under the supervision of the Department of Agriculture (DOA). All these plants were of floating drum type (Figure 1) designed by Khadi and Village Industry Commission (KVIC) of India. However, the national attention and momentum gained in the spread of technology drastically subsided as the "Agriculture Year" was over.

In 1976, few technicians were trained under the USAID/Nepal supported "Studies of Energy Needs Into the Food System" project.

In 1977, Gobar Gas and Agriculture Equipment Development Company Pvt. Ltd. (GGC) was set up in collaboration with (a) Development Consulting Services of United Mission to Nepal (UMN), (b) Agriculture Development Bank of Nepal (ADB/N), and (c) Fuel Corporation of Nepal (FCN). Thus, GGC as a private company became the first organization fully responsible to oversee the development of biogas technology in the country (Karki & Dixit, 1984) And for seventeen years since then, it remained the only organization responsible for the promotion of technology in the country. By 1978, the country had a total of 708 plants and all were of floating drum KVIC type.

The difficulty in transporting a heavy and big metal drum of KVIC design became a serious limiting factor for its wider use, particularly in remote areas As an alternative, a drumless design originally used in China was modified and the first drumless plant was constructed as an experiment in 1978 by the DOA This design became popular quite soon because of its lower initial investment cost compared to that of KVIC model Consequently, the construction of KVIC type plants were stopped by 1987 and all plants are now constructed of drumless design with concrete dome (Figure 2). The design parameters for all size plants are approved by Biogas Support Programme (BSP). Subsidy is not provided for plants that do not follow these standard parameters. This approach is taken after an evaluation revealed that more than 90 percent plants of these parameters were successful, which is a very high rate of success compared to that of other countries. However, the limiting nature of this approach is being cautiously modified to allow the promotion of other model plants such as*Deenbandhu* (Figure 3)

The different sizes of biogas plants constructed by various companies are 4 m^3, 6 m^3, 8 m^3, 10 m^3, 15 m^3 and 20 m^3 out of which 8 and 10 m^3 sizes are the most common. The average size of biogas plants constructed each year has been decreasing from about 10 m^3 in 1990 to 9.25 m^3 in 1995. Programs are being launched to bring this size further down to about 8 m^3.

Government Policies and Plans

It was in the FY 1975/76 that the Government of Nepal first took initiatives for the promotion of the biogas technology. In that year, the government provided interest free loan for families to install biogas plants In the following year, the incentive was changed to a preferential loan at 6 percent interest rate channelized through ADB/N. In 1982/83, a subsidy of NRs 5,500 was provided to each plant constructed in some specified districts only. In the Seventh Five Year Plan Period (1985-90), the government decided to provide a subsidy of 25 percent on the construction cost and 50 percent on the interest of loan from ADB/N. But these policy provisions were removed in 1990/91 in favor of the general policy to do away with credit subsidies. These frequent policy changes and their inconsistency had been the main bottleneck Since 1992, the policy has been to provide a subsidy amount of NRs 7,000 for each family size plant constructed with given design parameters. An additional NRs 3,000 is provided as transport subsidy for hilly districts. These subsidies are provided irrespective of the plant size

The government plan for construction of biogas plants was first included in the Seventh Five Year Plan (1985-90) with a target to construct 4,000 plants during the project period. It was considered an ambitious plan but was easily achieved Encouraged by this achievement, the Eighth Five Year Plan (1992-97) has set a target of constructing 30,000 plants, which is judged to be fully achievable before the end of the planned period.

The two important factors that contributed to the rapid increase in number of biogas plants are (a) the implementation of BSP with financial support from the Netherlands Development Corporation (SNV), (b) the government policy on privatization that prompted entrepreneurs to form new biogas companies (other than GGC) and the country now has 22 such companies: and (c) easier flow of subsidy through banks New biogas companies are registered with the government under cottage industries and they widely vary in their technical capabilities.

It is interesting to note that the government has to fully rely on the performance of the private sector for the attainment of the target that it sets because it does not have specialized agency or unit to oversee the planning and management of the biogas sector

Considerations are being made to establish a National Biogas Center (NBC) as a government entity to oversee the development and management of the biogas sector. The Ministry of Forest and Soil Conservation is now designated as the "contact" or liaison ministry to oversee the biogas sector program till the NBC is actually established.

4. ORGANIZATIONS INVOLVED IN THE BIOGAS SECTOR

Government Agencies

In the initial phase, especially during the Agriculture Year in 1975/76, the MOA was actively involved in the promotion of biogas technology To some extent, the Energy Planning Division of the Water and Energy Commission Secretariat (WECS) has also been occasionally involved mostly in studies for monitoring, evaluation and training. Largely, this sector has remained in the hands of private sector and the ADB/N which is a semi-government national institute for rural credit. However, proposal to establish a government body to oversee the biogas sector is under active consideration

ADB/N and Other Commercial Banks

ADB/N was established in 1968 and provides rural credit services through its above 700 field offices strategically located to reach even the remote areas of the country. From 1974/75 to 1995, it has been the only agency to administer loan and government subsidy for biogas construction Though a financial institution, it has also been involved in promotional activities such as information campaign and training in the biogas sector.

With the growing demand and need to wide spread the technology, other commercial banks have also started financing the construction of biogas plants. However, institutional credit facilities of these banks are limited to financing the individual plants only.

Donors, (I) NGOs and Consultancy Firms

Various donors such as SNV, United Nations Children Fund (UNICEF), Save the Children, USA, Plan International and FAO are involved in the promotion of biogas program in Nepal Their involvement is mainly for providing financial support and the necessary technical assistance.

The number of NGOs and consultancy firms involved in biogas is also increasing. Some of the prominent companies are: Consolidated Management Services Nepal, New Era, and East Consult. The activities of these companies are limited to conduct socio-economic research, program evaluation and training.

Biogas Support Programme (BSP)

BSP started in 1992 in collaboration of GGC, ADB/N and SNV. The short-term objectives of the BSP are (a) to support the construction of 20,000 plants (7,000 plants in the first phase i.e 1992-July 1994 and 13,000 in the second phase i e July 1994 to 1997) by providing subsidies through ADB/N, (b) to make biogas more attractive to smaller farmers in the hills, and (c) to formulate well-considered recommendations for promoting the private sector participation in the biogas sector Current activities of BSP include, recognition of biogas companies, widen access to credit for biogas, provide subsidy on biogas plants, quality control in the construction of biogas plants, research and standardization, training and extension, monitoring and evaluation, and support to policy and planning of the sector. At present, BSP is being implemented collaboratively by SNV, ADB/N and recognized biogas companies

Food and Agricultural Organization of the United Nations (FAO)

FAO has been supporting the promotion of biogas technology in the developing countries since many years. Recently, a project titled*Support for the Development of a National Biogas Program* is being implemented under Technical Cooperation Program of FAO The activities include mainly training of masons and biogas users and utilization of digested slurry as fertilizer.

Gobar Gas and Agricultural Equipment Development Company (GGC) and Other Private Biogas Companies

GGC has been the only organized body responsible for overall development and management of the biogas sector for 17 years i e from 1977 to 1994. Since 1994, more than 22 other companies have come up to provide construction services to meet the ever increasing demand for the installation of biogas plants.

5. POTENTIAL OF BIOGAS IN NEPAL

As pointed out earlier, biogas technology in Nepal is generally understood as a means to produce cooking and lighting fuel by feeding a digester primarily with cattle dung. With this limited view on the technology, the national potential is calculated on the basis of dung from cattle population that could be available to feed biodigesters in different parts of the country.

The total population of cattle and buffaloes in Nepal is estimated to be 9.3 million in 1990/91 and the number shows an increasing trend These animals produce about of 37.4 million tons of dung every year. Assuming that only 75 percent of the dung can be collected, about 28.1 million tons will be available for use in biogas plants (Wim van Nes, 1992). With these figures, Nepal has the potential to produce 673 million m^3 biogas annually which is equivalent to 4,038 GWh in terms of hydropower, or has the potential to substitute 390 million liters of kerosene costing about NRs 3,510 million or 3.7 million metric tons of firewood. In terms of average family size plants of 10 m^3, Nepal has a potential of establishing 1.3 million biogas plants

Based on the annual temperature, only 56 of the 75 districts of Nepal have been found suitable for proper operation of biogas plants The national average size of the potential biogas plants is 6 to 8 m^3 based on the number of animals raised by an average farming family. The biogas demand for cooking and lighting for the "potential biogas households", i.e., households that have enough cattle to have a biogas plant, is 878 m^3 per year which is 77 percent of the production potential

6. PERFORMANCE REVIEW OF BIOGAS SECTOR

Technical

Nepal has adopted the "single design and multi-private sector institutions" approach for the promotion of biogas technology in the country. The design in use was developed about a decade ago and has been found to be robust both in the hills and plain areas as more than 90 percent of the constructed plants were found to be functional. As stated earlier, this rate of success is very high compared to any world standard. However, cautious steps are being taken to move towards "multi-design and multi-institution" approach.

The most common problems related to biogas plants, in decreasing order of their magnitude, are (a) gas production lower than the plant capacity, (b) gas leaks from dome, (c) slurry in gas pipes, (d) blockage in inlet, (e) leakage from gas valve, and (f) poor quality construction. Other general problems that the sector suffers include the following.

(a) Because of the low investment capacity of farmers, the present level of government subsidy is considered low even though it meets more than 50 percent of the initial investment cost

(b) Inadequate post-construction services and user training.

(c) A general trend of decreasing number of livestock in the households after the construction of plants.

(d) With growing scarcity of water supply in urban areas, the water used to feed the plant is also in decline

(e) There is high variations in the materials used and the price charged by biogas companies from the beneficiaries.

(f) There is a tendency to construct an oversize plant because the technicians get more construction fee and farmers can get more loan from the bank for bigger plants.

Distribution

Out of 75 districts of the country. 19 districts have the potentials to establish less than 1,000 plants for the climate and population being the main limiting factors. The concentration of biogas plants is higher in the urban areas and in areas with easy access by road. This tendency is attributed to the increasing scarcity of household fuel in these areas and easy access for service institutions such as banks and biogas companies Increasing scarcity and price of firewood, easy access to credit facilities and technical services, and growing awareness have been the three main factors to motivate a farmer for installing a biogas plant. Of the total potential of 1.3 million plants, 62 percent is in plains, 37 percent in hills and 1 percent in mountains.

Economics

The average price of the popular size biogas plants, i.e. 8 m^3 and 10 m^3, in 1996 prices are NRs 22,000 and 25,000, respectively. The owner is eligible to receive a subsidy of NRs 7,000 in the Terai and NRs 10.000 in the hills for each plant constructed irrespective of the sizes of the plants. Loan can be obtained from ADB/N and other commercial banks which is payable in 7 years at the current interest rate of 16 percent per annum. The subsidy amount is sufficient to meet more than 50 percent of the construction cost. Depending on the access to road and availability of construction materials near the construction site, the construction cost could be brought down by as much as 40 percent (Karki, Gautam & Joshi, 1993).

For economic calculation of the plant, the price of kerosene is taken for comparison. A 10 m^3 plant under optimum working conditions, can produce 3 m^3 of gas (0.3 m^3/m^3 digester volume) per day Assuming that 1 m^3 of biogas is equivalent to 0.58 liter of kerosene and the price of kerosene being about NRs 9.00 per liter, a biogas gives an discounted (20 years) benefit of about NRs 5,715 per year. This simple calculation does not consider all other intangible benefits such as improvement in the environment and sanitation, improved health of housewives and so on.

Social Performance

A majority of biogas users are medium and large farmers As against the national average of 40 percent literacy rate, 80 percent of the biogas users are literate.

Women

A study carried out by B B. Silwal and R K Pokharel, in 1995 with 100 users revealed that about three hours of time is saved per day with the use of biogas, which otherwise would have been spent in cooking, cleaning of pots, and collection and management of firewood Use of biogas has shown positive impact on health of housewives specifically with respect to the headaches, cough and eye diseases. Even old asthma patients who could not cook before assumed the responsibility for family cooking after installation of biogas plant.

Research

Research is one of the most neglected parts of biogas sector in Nepal, both in terms of human and financial resources involved in it. The main focus of promotional agencies and the construction companies has been to increase the number of biodigesters in the country. GGC has been promoting the same concrete dome design (based on Chinese technology) for the past 14 years*Deenbandhu* model which replaces the concrete dome with a masonry one has already been developed and successfully tried out in some parts of the country. The brick-type *Deenbandhu* plant has been found to be at least 20 percent cheaper than that of GGC concrete plants (BNRM, No. 46, August 1994). However, studies by BSP have not shown significant difference in prices between GGC model and *Deenbandhu* plants

Research work such as increasing gas production during winter has been a subject of much concern to the beneficiaries The level of gas production during winter even decreases by about 25 percent in Terai and beyond 50 percent in the hills. Research on biogas production in cold condition was undertaken at Khumaltar Agricultural Farm, Lalitpur, Nepal some years ago by Division of Soil Science and Agricultural Chemistry of the DOA. The results had indicated that the insulated plants produced about 93 percent more gas than the uninsulated one and heating the slurry prior to feeding the plant is not effective to increase gas production appreciably.

Even the limited research carried out so far has remained within the laboratory. Not much has been done to explore the possibility of using alternative feedstock. Although more than 30 percent of the family size biogas plants in the country are attached to latrine, no systematic data are available on the effect of such practices Reduction in construction cost is another area of research priority that has remained untouched Use of local materials in biogas technology has not been given due consideration. Also. not much has been done to explore the possibility of locally producing biogas appliances

Training and Extension

By 1993, a total of 450 masons, 1,705 users and 115 construction supervisors were provided training. All these training were conducted by GGC as it was the only specialized institution responsible for the promotion of biogas in the country (Karki, Gautam & Joshi, 1993). In recent years, some of the newly established biogas companies have started providing training to their users with support from BSP especially for their respective biogas users Since training and extension activities do not bring direct profit, private biogas companies have been less active in these important areas of the technological promotion. Furthermore, there are neither government organization nor support available to carry out these activities Considering this, BSP has come up with some *adhoc* fund to support training programs.

At present, besides GGC, field staff of the DOA, ADB/N, biogas companies and donor agencies like SNV are involved in motivating and educating farmers on the benefit of installing biogas plants. However, these extension activities are not coordinated and in most cases technicians are not adequately trained to undertake such work. Usually, the manure and sanitation value of biogas technology are ignored in such extension efforts. Only a limited number of women are involved in the extension activities (Leemakers, 1992).

Institutional Strengthening

Institutional strengthening is yet another neglected area in the biogas sector. Other than the creation of GGC in 1977, there is no evidence of any program or support for strengthening institutions and building up institutional capacity in the country. Though BSP was not designed to include institutional strengthening component, it later took up initiative to fill this gap that ever existed. BSP supported studies to recommend suitable institutional arrangement and these suggestions are being actively considered by the government. The implementation of BSP recommendations would lead to the establishment of a national body to oversee all development programs and processes of the biogas sector

7. MAJOR ISSUES

One of the main issues concerning wider application of the biogas technology has been the limited view held on the technology itself It is narrowly viewed as the technology to produce cooking fuel from cattle dung The potential of the technology in terms of producing valuable organic fertilizer, treating urban waste, generating commercial energy and improving rural and urban sanitation is not a common knowledge in Nepal. As the technology has gained wide social acceptance and popularity as a family unit plant, it is high time for Nepal to apply the technology to ameliorate many of the problems that the society is currently pressed with, for example, the problem of urban waste management that has reached to a critical level. So far, all efforts are being directed to increase the number of household biogas units of a given design fueled by provision of the subsidy at a level that the government may not be able to sustain on its own. Absence of government support and grant for activities such as research, training and institutional strengthening has been the limiting factor for the sustainable development of the sector and the wider application of the technology.

Biogas promotion is largely a private sector operation in Nepal. Private companies make profit out of their services for construction of a plant. These private companies have very little incentive to carry out training programs, firstly, because the technical competence of these companies in areas other than the skill for construction is limited, and secondly, because the culture of paying for getting trained is yet to be well developed among the biogas users. And, there is no institutional framework to provide training in the biogas sector. At present, BSP as a project is filling this gap. The research aspect of the technology is also limited by these factors.

It is the life style of the "poorest of the poor" section of the population that is adversely affecting the sustainable farming in the hills. No special provisions are being considered for the socio-economically disadvantaged section of the population particularly when their life style of poverty is exerting negative impact on natural resources of common property nature.

All biogas related activities are run on a project basis and are guided by the availability of donor funding. They are yet to become a part of regular government programs with government department or ministry to oversee them on a sustainable basis.

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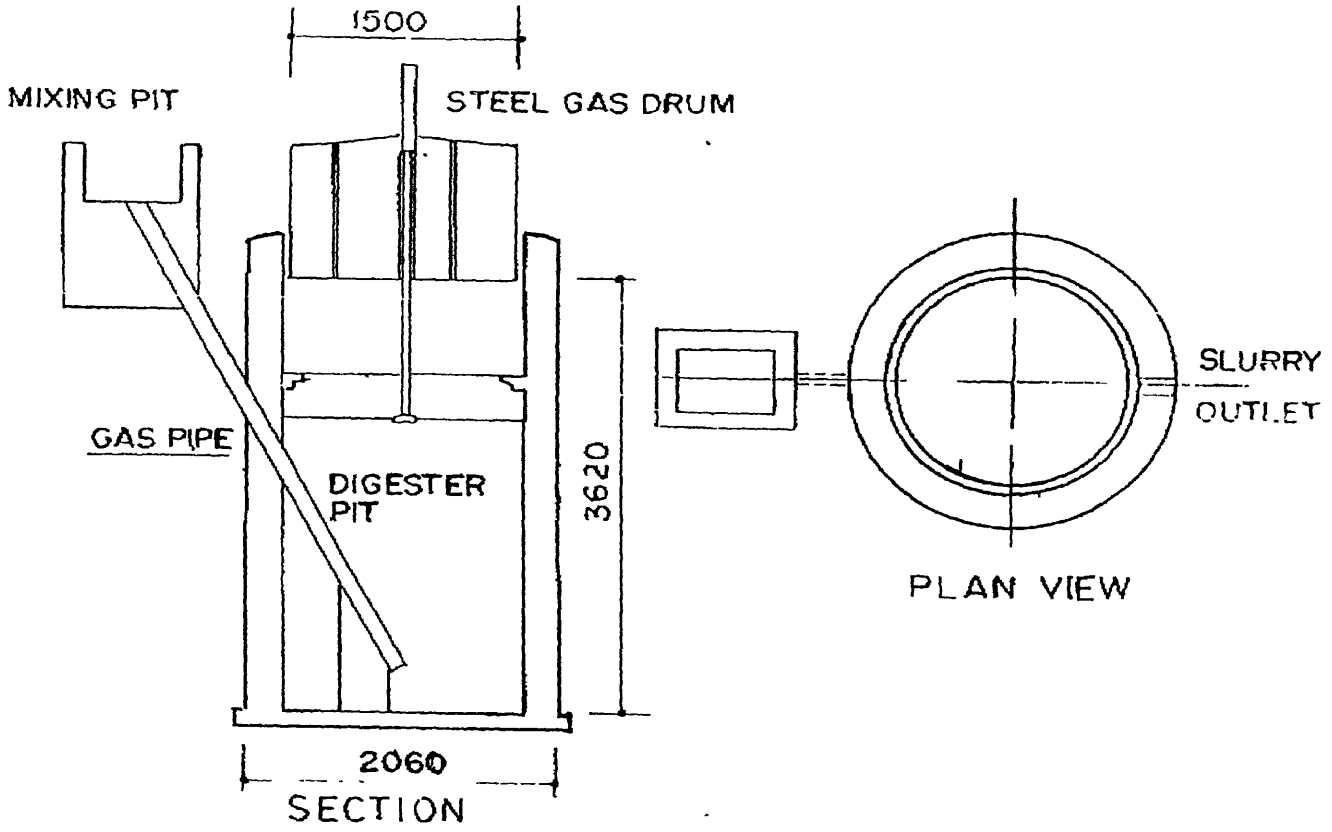
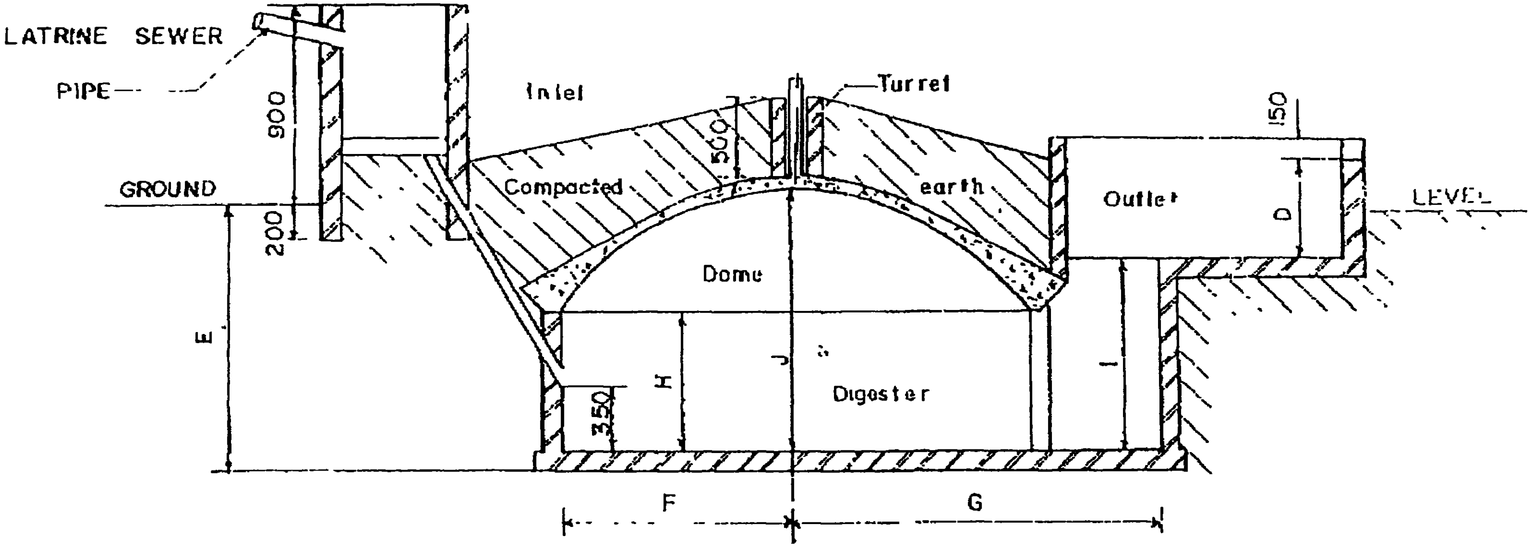


FIGURE-I KVIC FLOATING GAS HOLDER SYSTEM



SECTION

FIGURE:- 2 GGC CONCRETE MODEL BIOGAS PLANT

COMPONENT	PLANT CAPACITY (m^3)					
	4	6	8	10	15	20
A	1400	1500	1700	1800	2480	2640
B	1200	1200	1300	1250	1250	1760
C	1350	1510	1700	1830	2050	2330
D	500	600	650	680	840	860
E	1540	1550	1720	1680	1800	2030
F	1020	1220	1350	1540	1750	1990
G	1850	2080	2210	2400	2610	2880
H	860	920	1050	940	1150	1150
I	1120	1160	1270	1240	1320	1370
J	1510	1600	1750	1710	1930	2030

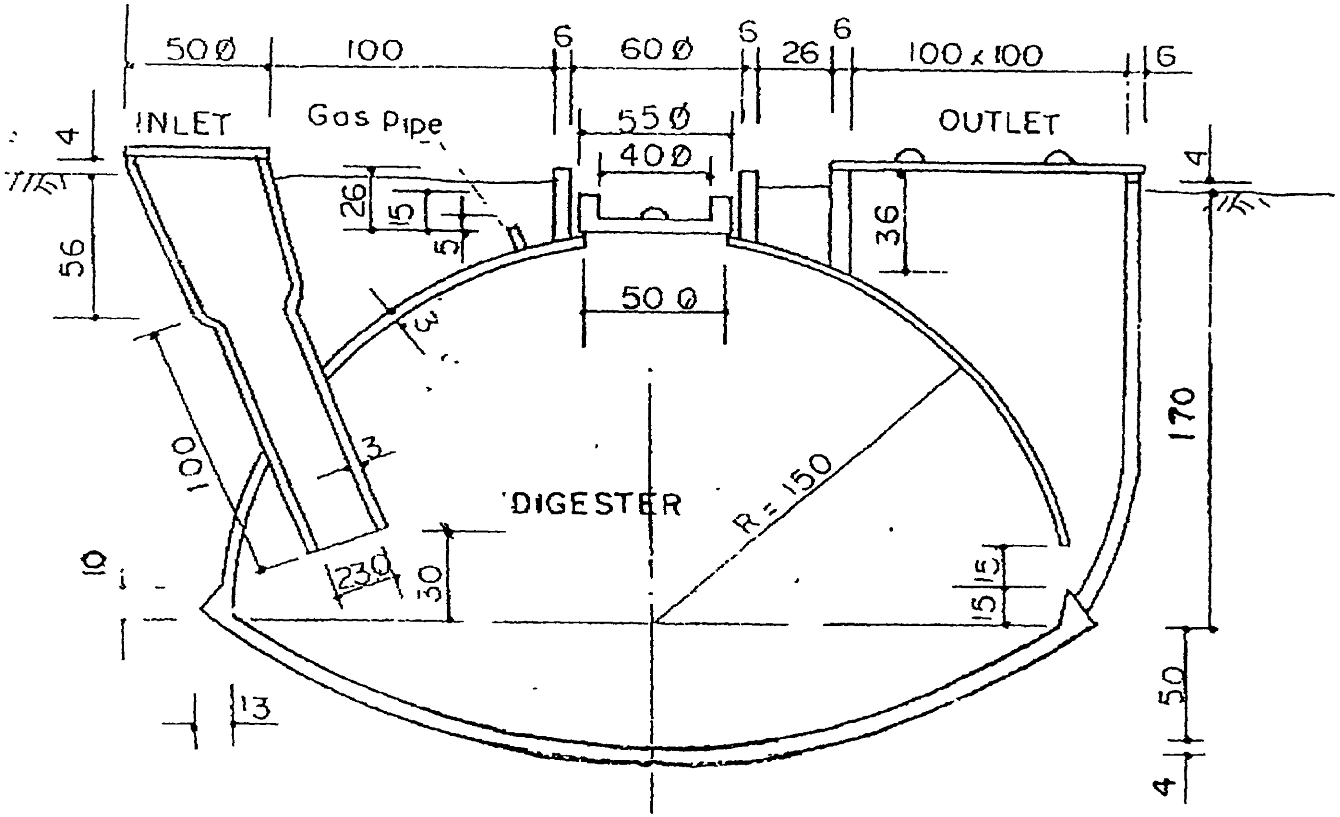


FIGURE:-3 BRICK TYPE DEENBANDHU MODEL BIOGAS PLANT

Biomass fuel consumption and formulation of Household Energy Strategy in Pakistan

by

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Biomass Fuel Consumption and Formulation of Household Energy Strategy in Pakistan

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Abstract

This paper presents an overview of the energy sector in Pakistan, with particular emphasis upon biomass fuel consumption by the household sector. It investigates the future role of woodfuel and crop residues in the overall energy mix, sustainability of supplies, and the manner in which biomass fuels trading takes place in the country Based upon an understanding of supply and consumption patterns, a long-term household energy strategy has been developed, consisting of three major components acting in an integrated and complementary manner. (a) the mechanisms for managing and orienting biomass supplies, (b) the mechanisms for managing and orienting energy demand, and (c) the institutional and community elements and/or agents participating in the promotion and implementation of the strategy Because of many similarities in biomass energy systems in the SAARC region, this strategy could provide useful insights in evolving policies and programmes for the sustainable development of biomass resources in other countries.

I Overview of the Energy Sector

1 Introduction Pakistan is endowed with large natural gas resources which were first discovered in the early fifties Similarly oil and coal reserves have also been discovered, and hydro-electric potential has been tapped to meet the energy needs in the country However, even with the natural endowment, Pakistan is dependent upon imported supplies, mainly in the form of crude oil and finished petroleum products from the nearby Arabian/Persian Gulf countries While the consumption of modern fuels is growing, a large proportion of households (mainly in the rural areas) are still using traditional fuels (firewood, crop residues and animal wastes) for a variety of socio-economic reasons Energy consumption levels are generally low (often at subsistence level) compared to other developing economies, reflecting the poor economic condition of a majority of the population The current national energy consumption of modern fuels is estimated at over 20 Million toe (at the end-consumption level), which has been growing at 6 1 % over the last five years. Of this, approximately 66% is supplied through indigenous resources at the primary-supply level, while the remaining is imported mainly in the form of crude oil and petroleum products In recent years, the cost of imported energy (crude oil and petroleum products) has been $ 1 5 Billion, which is almost 40% of the total export earnings of the country.

2 Traditional fuels (firewood, crop residues and animal wastes) are the primary source of energy for a majority of the rural population in Pakistan Reliable statistics on consumption of traditional fuels are not available, since these are not widely traded in the market However, it is estimated that traditional fuels supply an additional amount of almost 20 Million toe of energy, primarily to the household sector The consumption of these fuels takes place very close to the supply sources

3 Household sector The household sector accounts for approximately 54% of final energy consumption in Pakistan, and is thus the largest single energy consuming sector in the country Because of rapid population growth, it is also the most rapidly growing sector in terms of the demand on modern fuels This growth has placed a tremendous stress on the modern fuel supply infrastructure, resulting in electricity load shedding, natural gas rationing, fuel shortages and increased requirements for fuel imports and massive capital investments in the energy sector. At the same time, and in spite of the growth of modern fuel usage, the majority of households still rely on biofuels such as firewood, dung and crop residues Each of these biofuels alone supplies more energy (in terms of their latent value) to the household sector than all the modern fuels combined. In view of the rapidly growing population, there had been fears that woodfuels were becoming scarce, causing hardship, particularly to those low-income

households who rely exclusively upon the collection of those fuels as 'free' goods to meet their basic energy needs.

4. Field surveys. The major demand analysis survey was conducted under the Household Energy Strategy Study (HESS) Project over a period of one year, and collected energy and socio-economic information for World Bank's Living Standards Measurement Study. The primary objective of this survey was to develop the energy consumption patterns, and to develop the causal relationships, using the cross-sectional data base Satellite imagery, in conjunction with extensive field surveys, was utilized to take stock of the biomass resources, using variable sampling plots in different agro-ecological zones. Finally, extensive nationwide surveys were launched to trace the flow of woodfuel (and timber) from producers, wholesalers, transporters, retailers, and to the end-consumers. This survey enabled the project team to highlight the impediments in the woodfuel marketing system, and to propose different policy options. Residential Electricity Consumption Survey (RECS) was conducted by installing loggers for one/seven days period to understand consumption patterns, and contribution of the household sector to overall system peaks These surveys were undertaken and completed with the help of local professionals, staff of the counterpart agency, and specialists of ESMAP. Data bases were subsequently developed, and analytical work undertaken to formulate an integrated household energy strategy for Pakistan

5. Sectoral fuel consumptions Survey results indicate that the household sector accounts for approximately 54 % of total final energy consumption in Pakistan, equivalent to approximately 19 985 Million TOE in 1991 Table-1 shows the breakdown of total final energy consumption by different fuels and all the sectors, including households It will be observed that biofuels account for 86 % of total household energy consumption in Pakistan, while firewood alone accounts for 54 % of the total. Biofuels are principally used by households in traditional stoves to meet the bulk of their cooking, space-heating and water-heating needs Natural gas, used mainly for cooking in urban areas, is the most important modern fuel, accounting for 50.6% of total modern fuel consumption in the household sector. Electricity, used mainly for lighting and space cooling, accounts for a further 30.6%, followed by kerosene (15 7%), which is principally used for lighting, although also for some cooking. The remaining 3 2% is accounted for by LPG use, which has so far remained fairly small in Pakistan. No significant use of coal in the household sector of Pakistan was found during the survey

TABLE-1
PAKISTAN: FINAL ENERGY CONSUMPTION BY SECTOR, 1991
(THOUSAND TOE)

SECTOR	Elec	Gas	LPG-1	Petr Prod	Modern Fuels	Coal Coke	Wood	Dung	Crop Resid	Trad Fuels	Total Fuels
Households	851	1416	92	442	2801	119	10637	3613	2816	17185	19987
Commercial	190	275	31	522	1018	0	713	0	0	713	1731
Industrial-2	905	3290	0	1124	5319	2878	5	0	1353	4236	9555
Agriculture-3	458	0	0	1634	2092	0	0	0	0	0	2092
Transport-3	3	0	36	3729	3768	1	0	0	0	1	3769
Other/Govt	148	0	0	335	483	1	0	0	0	1	484
Total	2555	4981	159	7786	15481	2999	11355	3613	4169	22136	37618
Unit Household Consumption/year	1238 Kwh	40 2 Mcf	122 Kg	41 1 Litre		115 Kg	2324 Kg	1477 Kg	1161 Kg		

Source HESS Estimates for Household Sector, Energy Wing Estimates for other sectors

Note
1 Consumption figures for LPG in Commercial & Road Transport Sectors based on Energy Wing Estimates
2 Excludes 1259000 TOE of natural gas used in fertilizer sector as feedstock
3 Petroleum products consumption in Transport & Agriculture Sectors estimated by Energy Wing
4 Firewood consumption for Commercial sector estimated by HESS at 1 9 Million Tonnes

6 Wood supply Of the total energy consumed by the household sector, a predominant proportion comes from wood and other biomass resources such as dung and crop residues Evidence suggests that such heavy reliance on these fuels has a number of undesirable consequences, including environmental damages. The Biomass Resource Assessment component of the project aimed at developing a data base which would include, inter alia, the availability and supply of traditional fuels to the household sector.

For this purpose, a national agro-ecological zonation was created using multi-temporal Advanced Very High Resolution Radiometer (AVHRR) satellite imagery to distinguish between patterns of vegetation activity with time. The satellite imagery was obtained as monthly composites of daily images covering six annual growing seasons from 1982-87, then combined with ancillary Geographical Information System (GIS) data on rainfall, topography, climate, and the extent of irrigated farmland to produce a zonation of fourteen land cover types for the whole of Pakistan. This zonation provided a national sampling frame to link the supply and demand components of the project, and to provide a valid basis for extrapolating the results of the supply survey to the national level.

TABLE-2
PAKISTAN: AGRO-ECOLOGICAL ZONATION

Zone	Description	Area (Km^2)	Percent
1.	Hyperarid desert	58,738	6.7
2	Arid desert	193,604	22.1
3.	Transitional arid/semi-arid rangelands	117,833	13.4
4	Moderate productivity semi-arid	74,819	8.5
5	High productivity semi-arid	61,180	7.0
6.	Sub-tropical rain-fed agriculture	27,878	3.2
7	Permanent snow	25,019	2.9
8	High mountain valleys	18,964	2.2
9	Alpine and temperate scrub/forest	94,747	10.8
10.	Temperate/sub-tropical Himalayan foothill	10,637	1.2
11	Marginal irrigated	1,940	0.2
12	Moderate productivity irrigated	74,533	8.5
13.	High productivity irrigated	111,717	12.7
14.	Indus delta swamps	5,619	0.6
	Total	877,227	100.0

Source: HESS Survey, 1991

7 Sampling plan for woody biomass. Multi-stage sampling was used for the biomass supply survey to maximize efficiency. The agro-ecological zonation developed from AVHRR imagery provided the first stage of a multi-stage sampling frame. The second stage consisted of twelve scenes of Landsat Thematic Mapper (TM) imagery for a more detailed classification of the vegetation. Figure 5.1 presents the agro-ecological zonations and the location of these TM images. Sampling units were then selected by variable probability sampling from the digital vegetation classification from each Landsat scene, for field measurement of woody biomass and crop residues. Field teams were given precision-corrected satellite images and topographic maps to guide them accurately to each sampling unit.

8 Standing wood stock and annual productivity. The sampling methodology ensured that sampling units fell in areas of woody biomass vegetation in all agro-ecological zones throughout Pakistan. All woody biomass was measured, including commercial timber trees, all other tree species and woody shrubs. Mathematical models were also developed from destructive sampling of trees and shrubs to predict their biomass content by component (commercial timber, poles, large branches, small branches, twigs and leaves). Models were also developed to allow for the effects of crown damage due to lopping on tree biomass and growth. In order to estimate annual sustainable productivity, models were developed for trees and shrubs using both primary data from growth measurements in the field, and secondary data from forestry yield tables. Wood biomass resources, and annual productivity, was estimated for each agro-ecological zonation, and for different provinces. Salient results are as follows:

- Total standing stock = 210.78 Million Tonnes
- Total annual wood growth = 22.70 Million Tonnes

- Total fuelwood growth = 20.13 Million Tonnes
- Twigs/Leaves growth = 10.10 Million Tonnes
- Roundwood fuel growth = 10.03 Million Tonnes

9. Sustainability of forest resources The issue of biomass sustainability is complex, and cannot be addressed only from consumption viewpoint. It should also be seen from the viewpoint of the producer, and relationship of supply and equilibrium prices have to be also taken into account. The real importance of biomass sustainability lies in the associated issues of higher demand resulting in higher prices which in turn could increase the woodfuel share of the household budget, stimulate interfuel substitution, reduce woodfuel consumption, or induce some combination of the above effects. The sustainability of forest resources have a profound impact upon the groundwater recharge, soil erosion and fertility, microclimate quality, and the fragile ecosystems.

10. Agricultural residues survey. An agricultural residues survey was carried out to cover the cotton, sugarcane, maize, rice and wheat crops, both for Rabi and Kharif seasons. Samples were drawn from different areas in accordance with the agro-ecological zonation, and for different productivity conditions These samples were oven dried under specified conditions, and their resultant residual fuel values were carefully calculated Ratios between crop size and the agricultural residues were developed, and estimates for different agro-ecological zones, and at the provincial levels, made Following were the estimated quantities of crop residues.

- Cotton Sticks = 12.46 Million Tonnes
- Maize = 3.47 Million Tonnes
- Sugarcane (Bagasse) = 12.88 Million Tonnes
- Rice = 8.16 Million Tonnes
- Wheat = 20.65 Million Tonnes

11. Cotton sticks are most commonly used as fuel by the households Bagasse, as a by-product of sugar-making process, is used as industrial fuel by the industry itself Remaining residues are generally used as fodder for the cattle rather than fuel. Agricultural residues are also used as soil conditioner by the farmers, and, therefore, the net amount available to be used as fuel is much smaller than the overall availability

II. Existing Wood Fuel Trading Structure

12 General features and patterns of trading. Firewood markets in Pakistan operate under an organized set of arrangements and structures, which are responsive to supply and demand conditions. The actual scale and efficiency of trading networks are regulated by a number of interacting factors such as local demand, transport requirements, supply locations, prices, etc. The manner in which traders cope with these factors is a function of certain basic features of their trading establishments About 40,412 businesses operate in firewood markets throughout Pakistan Roughly 32% are found in urban centres, 52% in villages, and the remaining 16% are located along metalled roads In addition, about 4800 timber traders also sell wood, though at lower levels. Retailers dominate the firewood market in numerical terms totaling over 36,000 or 91%. Sales to the household and commercial sectors comprise the bulk of their revenue. Retailers are unevenly distributed throughout the country with the highest percentages found in the Punjab and NWFP. Most traders sell retail as well as wholesale. There are few "pure" retailers or wholesalers that sell exclusively to either households or other traders About 65% of all traders recorded sales to each of the three types of buyers, forming the backbone of the market Roughly 30% concentrate solely on the household sector, while only 5% target other traders exclusively.

13. Firewood trading businesses are generally small scale operations that remain open year-round. About 71,848 people were working on a permanent basis during the winter of FY92, roughly 87% in retail A further 26,928 people were employed as part-time staff. Altogether, 98,775 people were

engaged in wood markets, about one out of every 1185 people in Pakistan Approximately half of all traders also stock other fuels and materials for sale. Primarily, these products include timber, its sawdust derivatives, and charcoal. Most of the traders who also sell timber are located in the NWFP and Punjab provinces, where they have easier access to public auctions of timber from government forests Seasonal variations are in clear evidence for the firewood trade Winter sales are roughly twice the level of summer sales Seasonal variations are more pronounced for retailers, whose summer trading activity drops to approximately 38% of winter sales while only dropping to about half for wholesalers Monthly expenses per trader depend on location and type of trader Wholesalers have roughly double the monthly expenses as retailers Urban wholesalers are paying higher rents than any other type of trader Rural wholesalers show a disproportionately higher monthly budget for temporary staff

14 Supply and critical links in the distribution chain Most rural-based wholesalers obtain their supplies directly from private farmers, confirming the importance of these supply sources to the firewood trade Urban retailers have the shortest distribution chain, as most do not venture into rural areas to procure their supplies preferring instead to buy from large wood depots located just beyond municipal borders, or from local wholesalers According to trader perceptions, supply problems exist particularly for those located along the metalled roads This suggests that wood markets are inter-dependent, and competition for limited winter wood stocks is keenest for all but the urban retailers, most of whom do not buy directly from private farms Unlike other commercial products, firewood has no easily traceable, standard distribution route It is supplied from either private wood producers or government forests Upon entry into the market, it weaves its way to the final consumer after any number of intermediate levels of exchange between traders

15 Private farmers in Punjab are crucial players in supplying firewood markets with nearly 90% of all farmers who sell their wood to local traders Wood producers generally tend to be large land-holders About 75% of the farmers surveyed indicated that they planted the trees themselves, and the predominant species planted are 'Shisham' and 'Kikar' There is only marginal involvement of tree producers in the inner network of the firewood trade Their role is primarily that of resource supply preferring to leave the actual parameters of wood market entry up to the traders, which puts them at a disadvantage. Except in Baluchistan, most farmers sell their wood on a standing tree basis The sale prices of wood producers vary on the basis of tree type and quantity sold. The price for all sales ranged from Rs 125-1000/ton, with an average price of about Rs 450/ton 'Babul' prices are the lowest, fetching about Rs 350/ton, while assorted other species fetched roughly 50% higher prices (Rs 530/ton) Most of the wood sold in a province originates in the same province This situation holds true for every province except Baluchistan, where firewood is drawn mostly from the neighboring Sindh province This pattern of cross-province transport reflects physical scarcity of wood resources in this province

16 Sales structure, prices and margins Winter monthly firewood sales were 1 822 million tonnes during FY92 This amount included 1 43 million tonnes that were sold directly to the final consumer as well as 0 392 million tonnes that were sold to other traders On an annual basis, the wood trade in Pakistan approached 16 million tonnes during FY92, or roughly 135 kg/capita/year The sale structure of wood markets is retail-dominated Annually, about 12 4 million tonnes are sold to the final consumer compared to 3 4 million tonnes sold to other traders. For retailers, the wholesale portion of monthly winter sales was almost zero for NWFP and Baluchistan retailers. For wholesalers, the retail portion of winter monthly sales is roughly a quarter of their trade Most of the wood trade is taking place in the northern part of the country Of particular note is the situation in rural areas of the NWFP, where retailers account for 56% of the total sale to rural consumers

17 There are significant variations in purchase prices across provinces. This range extends from the lowest price paid by Sindh traders to the highest purchase price paid by traders in large urban centres. These fluctuations tend to even out when considered from the perspective of trader location There is a general consistency for purchase prices for urban, rural and roadside dealers. Each is within 6% of the national average, and suggesting a competitive market system Selling prices also show significant variation across provinces. Except for Baluchistan, price mark-up are fairly consistent

throughout the country, coming to roughly 30%. For the case of Baluchistan, this mark-up can probably be explained by the higher transport costs involved and the attendant risks Net margins show considerable variation per province and trader location. Sindh traders show the lowest profit margins at Rs. 23,000, while Baluchistan traders show an uncharacteristically high annual net margin at Rs. 108,000.

18. Firewood transportation The most common form of wood transport is by truck, of which there are about 100,000 in the country. Most of these are employed in a wide variety of transport items in addition to firewood. The trucking agencies which are heavily involved in wood transport tend to be small to medium sized, and remain busy throughout the year. The most common truck is a 6-wheeler Bedford with a 8-ton hauling capacity Wood transporters are characterized by a relatively recent entry to wood markets. There are wide variations between agencies regarding the number of trucks contracted out for wood transport Most carry out between one and eight wood hauling trips per month and average about 512 km/month. About 50% of the wood which is transported is generally medium diameter round logs Most of the rest are large diameter round logs. The transport of firewood involves substantial distances and freights. Baluchistan trader show the highest average distance travelled Punjab traders, regardless of location, show the lowest average transport distance. This is due to the fact that they are in close proximity to farmlands from where they obtain the overwhelming majority of their supplies

19. Transport costs figure prominently in the price structure of firewood. They account for 67% of en-route and yard arrival costs Costs are lowest for roadside traders operating closer to farm sources. The tariff structure used by transport agencies includes a fixed overhead and a distance-dependent freight cost Average wood transport costs are estimated at Rs. 0.53 per tonne-Kilometer for a fully loaded 8-tonne truck Transit taxes show wide variation per province. Zila and octroi taxes vary from 9% in Sindh to 34% in the Punjab. The lowest percentage of taxes are paid by rural traders (12%), yet are not significantly different from the share paid by urban traders (17%), who may transport their supplies across tehsil and municipal boundaries. Compared to other costs, overall transit taxes take up the same share (16%) as costs involved in unloading and other yard arrival tasks. The fluctuations in transit taxes undoubtedly affect the price structure throughout the country.

III. Future Role of Biomass Energy

20. Household Energy Projection Model. An analytical demand projection model was developed based upon HESS survey, and is structured upon the disaggregation of households into five groups representing principal energy consumption patterns (See Annexure-I) These groups correspond to rural/urban location, use of electricity and use of natural gas Relationships between fuel consumption, and other demographic and economic data were statistically derived from the HESS database for each of these groups. Residential energy consumption patterns evolve as households move between groups, and as average household behaviour changes within groups. This evolution occurs in response to changes in the independent demographic and economic parameters. Some of these demographic and economic drivers consist of exogenous variables outside the domain of government energy policy (population growth, rural/urban migration, changes in household size, household expenditure growth, etc), and are modelled probabilistically. Other drivers represent government policies, such as fuel prices, gas and electric connection rates, appliance efficiency standards, and are modelled as user-defined choices

21 Demand scenarios. Four different scenarios for estimating the long-term energy consumption for the household sector were defined as follows. (a) baseline scenario, (b) accelerated natural gas and electricity connections scenario, (c) economic pricing of natural gas and electricity scenario, and (d) improved electric end-use efficiency scenario. The baseline scenario assumes the continuation of current policies i.e number of new gas and electricity connections are according to GOP targets (adjusted according to actual achievements in the past), LPG network in rural areas assumed at current level, kerosene and LPG prices bearing the same relationship to crude oil as in 1991, and prices of other fuel remaining unchanged in real terms Under the accelerated connection scenario, the number of new gas

and electricity connections are increased by 10% over the baseline case, upto a maximum of 95% electrification/gas connection level. Under the economic pricing scenario, gas tariffs are doubled by 1998 (in constant 1991 terms), and increases these to 60% of economic cost by year 2003 (at expected crude oil prices, this value is approximately Rs. 105 per Mcf), and subsequently increases these to parity with economic costs by 2008 Similarly, for electricity, the average tariff is increased to Rs. 1 00/KWh in 1998, and to parity with economic costs (a levelized Rs. 1.67/KWh) by 2003. Under the improved efficiency scenario, certain assumptions were made on efficiency improvements (and hence lower unit consumptions) for lighting, fans and refrigerators.

22. Demand projections for baseline scenario. Table-3 presents the energy demand projections upto year 2008 for the baseline scenario, based upon a number of macro-economic exogenous and policy variables, transition among different consumption groups and consumption patterns of these groups.

TABLE-3
PAKISTAN: HOUSEHOLD SECTOR FINAL ENERGY DEMAND

FUEL	Units	1991 Estimate	1991-93	8th Plan 1993-98	9th Plan 1998-03	10th Plan 2003-08	1991 Actual	% Error in 1991 Estimate vs Actual
Electricity	GWh	9,923	11,552	16,527	23,987	34,440	10,455	-5 1%
Natural Gas	MMcft	55,815	64,980	95,259	139,675	203,724	60,531	-7 8%
LPG	MT	88,714	112,360	189,525	298,165	422,126	85,242	+4 1%
Kerosene	Mil Lit	565	596	621	642	682	564	+0 1%
Firewood	000 MT	29,913	32,217	38,582	44,605	51,111	29,380	+1 8%
Dung	000 MT	12,879	13,585	15,338	16,796	18,186	13,309	-3 2%
Crop Residues	000 MT	8,389	8,709	9,508	10,254	11,174	8,301	+1 1%

Source Household Energy Policy Analysis in Pakistan, Final Report, May 1993

23. Trends and transitions. Significant trends in household energy consumptions, and inter-fuel transitions, are as follows. (a) electricity consumption increases nearly 350% between 1991 and 2008, with increasing incomes accounting for only about 15% of the increase i e if no more connections were added, total household electricity consumption would be expected to grow by about 50% over the same period; connection rate is the principal driver of this increase; (b) natural gas consumption follows a similar trend, as per household consumption among users increases only by 20%, but the increase in connection facilitates the bulk of the 365% increase in total consumption; (c) Alternatively, the increase in LPG consumption is driven primarily by the increase in household incomes, as increasing incomes allow households to move quickly from kerosene to LPG, or skip kerosene altogether as a cooking fuel and move directly from woodfuel to LPG, (d) although there is some increase in woodfuel use per household (of the order of 15-25% depending upon the group), the 71% increase in total woodfuel consumption is primarily attributable to population growth, and the remaining growth in total consumption appears to be a result of interfuel substitution away from crop residues and dung, facilitated by income growth, (e) dung and crop residue use remains constant (or fall depending on the group) on a per household basis, however, population increases cause 41% and 33% growth in total consumption, respectively, and (f) approximately 65% of households will continue to cook with biomass (though not exclusively), compared to 80% today, and biomass will remain an important component of the household fuel mix in Pakistan

IV. Household Energy Strategy Study

24. Objectives of household energy strategy. Based upon the results of different surveys, and the household energy issues, a 10-year household energy strategy is being outlined which would assure balanced and sustainable development of this sector. The basic principles of the proposed strategy are as follows (a) continue to offer households a broad choice of fuels for different enduses, and there should be no forced government intervention for inter-fuel substitution, (b) irritants (government controls, levies) must be removed, so that the energy market could operate on a more competitive basis; (c) the largest possible participation on the part of the private sector and the community must be obtained in

implementing the strategy, and the government must restrict its role as the facilitator; (d) seek alternative household energy systems and fuels that are of lowest economic cost to the country, and also ideally result in economic advantage to the households; (e) actions to replace partially firewood as a household fuel, so that regional imbalances and threat of deforestation could be averted; (f) maintain prices of petroleum products, natural gas and electricity for the household sector at their true economic values, but keeping into account the welfare considerations of the poorer sections of the society; (g) rational use and energy efficiencies in the household sector must be promoted through a system of incentives, and (h) the household energy strategy is institutionalized in the overall planning system, and progress is monitored on a periodic basis

25. Strategy components The household energy strategy consists broadly of the mechanisms for managing and orienting energy supplies, the mechanisms for managing and orienting energy demand, and the institutional and community elements and/or agents participating in the promotion and implementation of the strategy These mechanisms and institutional and community elements act in an integrated and complementary manner to achieve the overall objectives of the strategy Within this broad framework, four specific programmes encompassing these components are as follows (a) overall demand management and prices, (b) sustainable supplies and fuelwood production, (c) commercial fuels infrastructure and interfuel substitution, and (d) institutional development

V Overall Demand Management and Pricing

26. Demand-side management HESS and RECS have indicated potential for Demand Side Management (DSM) measures to rationalize the peak load demand of the household sector Shifting of certain household loads (water pumps, electric iron, etc) from the morning-peak to non-peak hours can result in flattening the demand curve. Government had also experimented with the day-light savings programme, and its results on the peak load demand should be carefully evaluated Because DSM for households has to be voluntary, awareness campaigns and outreach programmes have to be organized to educate households in reducing their consumptions, without any sacrifice of welfare Advisory services on building construction, insulation, etc needs to be provided alongwith recommendations on installation of electric and other equipment, and its efficient utilization.

27. Enduse efficiency improvement and equipment standardization. The study findings suggest that the introduction of high efficiency appliance programmes is economically justified for most appliance utilization Economically justified measures for lighting, refrigerators, and fans could reduce the year 2008 economic cost of residential electricity supply from approximately Rs 58 billion to Rs 48 billion in 1991 terms. This estimate of total technical potential takes into account the penetration rates expected under an aggressive appliance efficiency programme. Similar programmes for natural gas/LPG and kerosene equipment standardization, and enduse efficiency improvement would result in rich dividends to the economy

28. Efficient fuelwood stoves Since fuelwood consumption represents a large proportion of household energy mix, efficient wood stoves offers a great potential for rationalizing consumption and bringing it in line with supply However, this option has not made a great deal of progress primarily due to the following reasons: (a) efficiency programmes have generally under-estimated the efficiency of the open-hearth or traditional 'chula', with the result that fuel-efficient stoves do not demonstrate the promised savings; (b) designs of the fuel-efficient stoves are actually less-efficient than open fire (in particular, the bodies of the high-mass smokeless stoves absorb too large a share of the heat to be as efficient as simpler metal bucket design); and (c) inconvenience involved in using the fuel-efficient stoves A designated agency should formulate and coordinate a fuel-efficient stove programme for the household sector, keeping in view the experiences gained so far and the above factors

29. Energy pricing for demand management The findings of this study suggest that it should be possible to design a tariff structure in which retail electricity and gas prices increase substantially by 1998

and reach economic parity by 2003 (for electricity) or by 2008 (for natural gas), and in which no income category will face an increasing fuel budget share. Increasing tariff will not only dampen demand (and thereby reduce the economic costs of electricity and gas consumption) but will improve the financial viability of electric and gas utilities in Pakistan. Also, the number of slabs in domestic sector electricity and gas tariffs should be reduced, and Fuel Adjustment Surcharge (FAS) needs to be made adjustable, and flat rates done away with

30. LPG pricing policy should be sensitive to gas pricing and availability, but increasingly should reflect its own market characteristics, as gas prices are rationalized. LPG prices should be maintained at the import parity level, and regularly adjusted to reflect the actual import versus domestic supply balance. The current relatively high import price allowed as a basis for fixing LPG retail price, provides incentives to increase both imported and domestic supplies, and for suppliers to finance necessary cylinder, transport and storage/distribution costs from the profits realizable on LPG sales. Once the consumer cylinder and appliance costs are overcome, the LPG cost (at higher levels) has been shown to be relatively competitive with other fuels. For domestic LPG supplies, producers should be encouraged by allowing import-equivalent price levels and by adding incentives for remote locations. For downstream bottling and distribution activities, tax credits and related price incentives should be established, to stimulate investments by the private-sector in bottling, transport and storage facilities. Also, price determination should be made only at the regional terminal level, and not downstream through marketing to the final consumer A regional wholesale price reference would allow supplies to move more effectively in response to profit incentives and reduce the unreported market. This policy should, however, be accompanied by efforts to limit allowable final price levels, and to police competitive practices to ensure that market abuses are not occurring in the transition

31. Kerosene price levels should be formally linked to a crude oil plus refining/distribution cost equivalent level, with regular adjustment made in response to import market conditions Prices should be increased to parity with diesel, and otherwise 'marked-up' over crude oil cost sufficiently to recover kerosene's contribution to the necessary investments in refinery expansions and upgrades required to meet market demand As with LPG, price determination should be done only at the regional depot-level. A kerosene pricing structure, more reflective of regional cost differences, will encourage supplies to move to their highest value market, and stimulate inter-fuel competition and conservation in the process.

VI Sustainable Supplies and Fuelwood Production

32. With careful management and planning, fuelwood can provide sustainable energy future for Pakistan's households However, in order to have such a situation, a number of steps have to be undertaken as follows (a) transition from reliance on old-growth trees to farm trees, deliberately planted and managed on private farmlands, to supply major fuelwood requirements, (b) proper woodfuel management has to be done, and policy efforts should focus on supporting peoples's initiatives at tree planting, interfuel substitution, and fuelwood conservation, without undermining it through subsidies or give-away policies, (c) stimulating the demand of timber in the country (75% of any tree ends as waste product usable as firewood) can help in ensuring sustainable fuelwood supplies; and (d) consistent government pricing policies for household sector fuels (natural gas, kerosene, LPG), increasing availabilities, removal of subsidies, promotion of efficient fuelwood stoves, etc would rationalize the fuelwood consumptions and bring it in balance with the sustainable supplies.

33. Conscious policy of no government intervention Governments can normally achieve little, if anything, by trying to intervene in the workings of privately-run fuelwood and timber markets. In Pakistan, there is anyway little need to intervene, because the system of wood trading and transport appears to be working effectively and with good economic efficiency. The large number of traders and the diversity of transport and trading channels ensures a high degree of competition. Most traders are making reasonable but not excessive incomes from their businesses. Government policy should be to maintain this private market system with the minimum of intervention.

34 Promotion of farm tree plantation and social forestry. Land use alternatives are too important to be dictated by relatively narrow policy objectives such as increased wood production. Farmers should be left free to make educated choices on using their land in the most productive and sustainable ways, which would often include a significant emphasis on tree growing. The approach of the government in promoting farmland trees should, therefore, follow a hierarchical structure leading from broad objectives to more specific tree-oriented levels i e. first, to devise policies aimed at promoting sustainable land use generally; second, to provide farmers with good and locally relevant information on tree growing as a business enterprise; and, third to provide incentives for social forestry so long as these do not conflict seriously with other land use objectives.

35 Improvement of information/advice to farmers on tree-growing and marketing The quality and extent of information/advice to farmers on growing and marketing trees has an important implication for sustainable fuelwood supplies and production Some of the major deficiencies are (a) the management of farm trees, (b) the manner in which wood is harvested; and (c) the manner in which the wood markets are operated. Advice through extension services, literature and broadcasts, etc, on these issues should be given a high priority in the development of strategies to promote farm forestry Information may need to include species choice, management practices such as pruning, thinning and rotation periods for various products, estimation of tree volumes and weights at the time of sale, and decisions on whether to sell standing trees to a trader or felled trees delivered to buyers. As part of this approach, provincial forestry departments need to monitor the development of expected wood demand from new wood-based industries, including pulp and paper, to ensure that future supply and demand will be atleast approximately in balance

36. Replacement of subsidies, and improvement of credit facilities/financial incentives. Provincial forest departments have been promoting farm forestry by subsidies of various kinds HESS and other surveys point out to the fact that farmers planting trees without the aid of subsidies, in the expectation of making good profits from sales to new wood-based industries Furthermore, the economic analysis on block plantations versus major agricultural crops shows that subsidies in the first years of plantation establishment make little difference to economic competitiveness, which is dominated by the price of wood, tree growth rates and the discount rate employed Policy-makers should, therefore, consider the replacement of subsidies by improved credit facilities for tree growing. Farmers can generally raise loans for agricultural crops, but find it difficult or impossible to raise them for tree crops Central and provincial governments forest departments should consider raising this issue with the Agricultural Development Bank and other lending institutions. Improved credit would have a similar incentive, as with subsidies, on tree growing without any charge on public funds

37. Establishment of rural and semi-urban associations for firewood extraction HESS survey clearly indicates that almost the entire rural population using firewood is 'collecting' - and not purchasing. Fuelwood trading is confined primarily to large cities and towns. It is estimated that autonomous collection of firewood is done from dead branches and discharged cuttings throughout the rural areas, however, country's forest resources and farm trees do not have the capability to generate the dead branches and/or cuttings in the required quantities, and illegal cutting is resorted to meet the firewood needs. The establishment among rural and semi-urban communities of associations for firewood extraction is a critical condition to reducing uncontrolled firewood exploitation. This step requires very careful consideration, as communities should be involved fully in the formation and running of these associations, and government should only act as a facilitator. These associations should take into account the firewood supply conditions in their particular areas, develop organized extraction programmes, encourage monthly payments (stumpage fee), organize collection and use of this fee for creating economic opportunities in their community for women and children, who traditionally collect firewood.

38. Removal of restrictions/taxes on firewood movements Federal and provincial governments should facilitate woodfuel trading by undertaking a country-wide review of taxes on wood transport across divisional/district boundaries, and permits and payments for wood harvesting The purpose of this

review should be to remove restrictions on movements (if any), and to simplify and standardize the procedures. The revised tax and permit system should be widely publicized, for example, at all transport check points The present tax system is onerous and reduces incentives for tree growing and effective marketing. It is grossly inconsistent and poorly understood, increasing opportunities for abuse and damaging exploitation of wood producers and traders

VII Commercial Fuels Infrastructure and Inter-Fuel Substitution

39. Electricity and natural gas networks. Given current gas and electric pricing for the household sector which is lower than the true economic cost, accelerating the rate of gas and electric connections will have high net economic cost, but will provide households with a higher level of welfare in non-monetary terms The only way to determine whether this welfare gain is worth the economic cost is to set prices to the economic cost of the fuel, and let households decide for themselves. Therefore, connection rates should be accelerated only if households are paying the full economic cost. However, even with this qualification, steps should be undertaken to enable the expansion of electricity and natural gas networks to meet long-term demands One approach to manage electricity demand is to combine policies for economic pricing and improved efficiency. This would reduce year 2008 electricity consumption to 22 7 TWh instead of the 34.5 TWh, estimated under the baseline scenario. Although this is still 229% increase over estimated 1991 consumption of 9.9 TWh, it is far less than the 348% increase of the baseline scenario. This approach may in fact be a matter of necessity, if Pakistan's chronic power shortage persists. Similar policies should be adopted for natural gas supplies. However, whatever policies are adopted, the magnitude of transmission and infrastructure development work should be evaluated, and concerted efforts and budgetary allocations must made to realize the targets.

40. LPG supply facilities By year 2008, total LPG consumption increases nearly five-fold under the baseline scenario The importance of planning for LPG supply infrastructure, therefore, should not be overlooked In the light of GOP's commitment to privatization, private sector should be given a major role in the expansion of LPG supply network. Investments will be required for (a) port facilities to handle unloading/storage of large shipments by sea, to take advantage of economies of scale; (b) trucks for transporting LPG from port storage to bottling plants, (c) bottling plants, and (d) LPG bottles. In addition, GOP should ensure that safety regulations are in place and strictly enforced.

41 Firewood transportation The transport of purchased firewood in the urban centres of Pakistan typically involves high tonnages over large distances by 6-wheel Bedford trucks. Not surprisingly, transport costs are the largest component of the wood purchase prices, accounting for 67% of enroute and yard arrival costs A variety of animal-driven or tractor trolleys are also used for hauling farmwood to the traders Costs are the lowest for roadside traders in Punjab and the NWFP, who operate close to farm supplies Any government intervention in pricing diesel oil is bound to have a major (and undesirable) impact on fuelwood prices. Government may facilitate the utilization of large-tonnage fuel efficient trucks and simplify procedures for fuelwood movements, so that traders do their business according to the market conditions.

VIII. Institutional Development

42. Setting up the institution for household energy development It is important to recognize the importance of household sector in the overall energy consumption in the country Within the overall mix, the dominant position of biomass fuels also calls for designating an institution for the long-term development planning of the household sector. It is felt that Planning Division (Energy Wing) should fill this role, and a specialized Cell is created for this purpose. This Cell should have a multi-disciplinary team of planners, however, due to its very nature, it will have to develop formal links with a number of other institutions in the country like the utilities and energy organizations, satistical bureaus, and forest institutes, etc

43 Development and updation of data bases and analytical work HESS and other related surveys

have provided a starting basis for creating a comprehensive data base on household consumptions, biomass resources, and annual sustainable productivities However, all these surveys were snapshots for a single year, and can say little about the changes which may be occurring over time. Similarly, fuelwood supplies from farmlands can be affected by crucial factors such as planting and felling trees, establishment of boundary trees versus block plantations, or farmers attitudes to trees versus other agricultural activities It is, therefore, important to establish regular surveys to collect key data on household consumptions and biomass supplies (tree plantation, management, production, costs, revenues, prices, etc), on a consistent format for comparability of results It is felt that designated national institutions should be involved as a project team, to utilize their specialized strengths, share data bases, and undertake analytical work on a continuous basis

IX Conclusions

The importance of biomass fuels in the overall energy mix, particularly for the household sector has been clearly manifested It is also evident that this importance is likely to continue in future on account of rapid population growth, and increasing consumption levels, regardless of aggressive electrification or gas distribution policies It is, therefore, of an utmost importance to formulate and implement a medium- and long-term household energy strategy, which could help avoid undesirable consequences of a mismatch between sustainable productivity of biomass resources and actual consumptions. Such a strategy inevitably has to be multi-pronged; it has to address the larger issues of demand management; present policy measures for enhancing sustainable fuelwood production; and provide guidelines for the development of infrastructure of modern fuels Household energy strategy needs to be properly institutionalized in the overall planning framework of the country, and needs to be monitored and continually updated, for which clear responsibilities have to be assigned The structure of the household sector in many SAARC countries is similar to that of Pakistan, and it is anticipated that the broad principles could be equally applicable in these countries in the formulation of such a strategy

ANNEXURE 1 Mathematical Formulation of Household Energy Projection Model

Group Definitions

1 Five consumption groups within the household sector are defined, and their consumption patterns identified (type of fuel and average quantities consumed), on the basis of 1991 HESS survey, as follows

- Group 1 Urban, Electrified, Gas using households (9 0 %)
- Group 2. Urban, Electrified, No Gas households (15 5 %)
- Group 3 Urban, Non-electrified households (6 5 %)
- Group 4 Rural, Electrified households (28 3 %)
- Group 5 Rural, Non-electrified households (40 7 %)

According to HESS survey, the urban/rural proportion is 31 69, of the 31% urban households, 79 % are electrified while the remaining are without electricity In the 69 % rural households, only 41 % have electricity In the urban electrified households (79% of 31% urban households), only 36 7 have access to natural gas

Mathematical Formulation

2 Mathematically, the model is formulated as a discrete-time dynamic system as follows

$$e(k) = p(k)\,C(k)$$
$$\text{and } p(k+1) = R\,p(k)$$

where

e(k) is a seven-element vector with elements representing the total physical consumption of various fuels in period k The fuels considered are electricity, natural gas, LPG, Kerosene fuelwood, dung, and crop residues The economic cost of household fuel supply is derived by multiplying these physical quantities by the economic costs of the fuels Household budget shares are calculated by multiplying these quantities by retail prices, summing them, and dividing by total household expenditure

p(k) is a five-element vector with elements representing the population (number) of households in each group in period k The population vector in any period is determined by its value in the previous period, and a set of rules R, governing household transitions from one group to another In short, these rules stipulate that

- The number of households in Group 1 (users of both electricity and natural gas, and located in urban areas) increases by the number of new gas connections
- The number of households in Groups 2 and 4 (electrified urban and rural households) increase by the number of new urban and rural electricity connections, respectively (although Group 2 additions are net of new electric connections already allocated to Group 1)
- The number of households in Groups 3 and 5 (non-electrified urban and rural households) increases by the growth in the number of rural and urban households net of rural/urban migration in excess of the new gas and electric connections

c(k) is a 5x7 matrix, with elements representing the average consumption of a particular fuel by households in a particular group. The elements of the consumption matrix are econometrically estimated from HESS database in the following form

avg consumption = availability % * user % * avg user consumption

where availability % represents the percentage of households in the group with access to the fuel (assumed to be 100 % for all fuels except LPG), user % is a logistic regression relating to the percentage of households using that fuel for that end-use to exogenous variables such as household expenditure, and avg user consumption is a linear regression relating average fuel consumption for users to exogenous variables

Inter-group Adjustments

3 Although HESS database indicates that all fuels are used by all groups (except where the group is defined by use of a fuel), not all fuels are modelled for all groups For example, LPG, kerosene, fuelwood, dung, and crop residues are not considered for Group 1, LPG use is not considered for Group 3 These fuels are omitted for these groups because they represent less than 0 1% of total consumption of that fuel, the small incidence of use makes it difficult to draw statistically significant conclusions about the consumption of these fuels in these groups 'Rural' (Group 4) natural gas use has been included in the analysis of Group 1 natural gas consumption

Biomass technology in Britain and Europe

by

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Abstract

Biomass is becoming again an important energy resource in Europe, as part of a new interest in renewable energy, especially for electricity generation and transport Pressure from Green parties and environmentalists has provided an incentive, while moves towards privitisation of electricity production in several countries has provided the opportunity

The disposal of wastes has provided a useful source of energy, through landfill gas, sewerage gas and incineration. Improvements in the process may be gained by using waste seperation, either at source or within the waste process stream, so that glass and metals can be recycled and also wet and dry wastes can be processed using anaerobic digestion or incineration as appropriate.

Energy crops is another area in which European countries are expecting to generate energy from biomass. Vehicle fuels can be derived from sugar crops, making ethanol to replace gasoline, or from vegetable oil crops, making rape methyl ester to replace diesel The use of wood from forestry residues or from short rotation coppice plantations to generate electricity via the gasification route is another area that is being carefully investigated The currently available downdraft gasifiers work well on a small-scale, less than 200 kWe, but are not considered economic. Technology under development, such as fluidised bed systems, are considered economic at a much larger scale, above 30 Mwe, but then transport costs may increase running costs. Gas clean-up systems need to be developed that would allow updraft gasifiers generating between 1 and 10 Mwe to be used economically and effectively.

Introduction

In the distant past, biomass was one of the most important sources of energy in Europe. The Industrial Revolution was started using charcoal. Many large forests were destroyed especially in Britain by the demand for charcoal. However, charcoal was eventually replaced by coal and then oil. Charcoal making as a tradition eventually faded out in 1950s. However, there has been swing back again in the past few years. Biomass energy is becoming a potentially important source of energy, especially for electricity generation

The context

Power production in Europe has traditionally been under the direction of large central producers. Most European countries have had nationalised industries in control of electricity generation, with large power stations based near the source of energy, which has usually been coal The size of the power station has been generally increasing in size, with the closing of smaller stations (< 50 MW) often within towns, and the building of new out-of-town stations over 1 GW in size The introduction of nuclear power has encouraged this trend, as nuclear stations work most efficiently, when they are big. The major change in the past few years has been the privatisation of electricity generation, which has allowed small-scale producers into the market Britain privatised the state-owned monopoly, the Central Electricity Generating Board in 1989. Other countries, such as Italy, have had some privately owned electricity production for several years, but are proposing to privatise their state-owned utilities.

In Britain, a political peculiarity has led to the government encouraging the production of energy from renewable sources, such as wind, water and biomass, especially by small-scale entrepreneurs. The Non-Fossil Fuel Obligation was set up in 1990 as a levy on fossil fuels that was designed to pay for the hidden extra costs of nuclear power Since this did not look very good to environmentalists, the government were persuaded to include support for a small amount of power to be produced by renewable sources. The NFFO proved much more popular than expected, with many entrepreneurs wanting to get into electricity production by this route The present stated government policy is to have 1,500 MW of Declared Net Capacity (DNC) from renewables by the year 2000

The NFFO works by asking for a series of bids by prospective electricity producers, tendering for the supply of a given amount of electricity, at price above that of the average market price of electricity. The bids are placed into certain bands according to the source of energy and a price is worked out for each band. The original cost for energy from wind was 11 p per kW hr, compared to a "pool" price of around 3 p The extra price was made up by using money from the levy on electricity generated from fossil fuels by the major producers The latest NFFO rounds meant that electricity distributors had to sign contracts with producers at

their asking price, as long as it was below a cut-off price, which was assessed based on the average of the prices offered by all the bids. The technology that has grown very fast in Britain under NFFO was been wind energy (Table 1) However, biomass energy, in different forms, has come a close second.
Other countries in Europe are following a similar trend, although in different ways. Many of the big state electricity corporations are being privatised, such as ENEL in Italy and EdP in Portugal There is pressure from the Green parties to see more electricity generated from renewable sources and some governments, such as that in Denmark, are providing strong incentives to build such plants Denmark has the strongest wind industry in Europe, and the parts of most of the windmills built in the UK are manufactured in Denmark. The Danish government is keen to encourage the ownership of devices such as windmills by local co-operative groups and local government groups, as well as by individual businesses. Norway, Sweden and Finland have a large proportion of electricity from renewable sources, since they have large hydro-electric resources. They also have a large timber industry, so have traditionally used wood as a source of fuel for domestic heating. They are therefore among the leaders in Europe in developing renewable energy technologies, especially from biomass Most European countries now have schemes for encouraging the production of electricity from renewable energy sources, such as biomass, by paying a guaranteed premium price to producers

Technology	NFFO 1&2 1990 1992			1993 Actual	NFFO3 1994		
	No	MW	price	MW	No	MW	price
Wind	58	96.6	11	124	55	166	4 8
Hydro	38	23	6	1438	15	14	4 5
Landfill gas	53	84	5.7	77	42	82	3 8
Sewage gas	26	33	5.9	104			
M&I Wastes	14	312	6.6	52	20	242	3 8
Farm Wastes				25	6	104	5 1
Gasification					3	19	8 8
Other	8	76	5.9	0.3			
Total	197	624		1820	141	627	
Total (all 3)					765	1251	

Table 1. Contracts signed for Renewable Energy Projects under NFFO

Notes: "Other" under NFFO 1&2 are mainly farm waste projects

By Feb 1995, 340 MW from NFFO 1&2 were declared operational, generating electricity and selling it to the grid

The "pool" price for electricity from fossil fuels floats between. 3 to 4 p per kW hr

Energy from Wastes in UK and Europe

One major concern of many local government groups in Europe is the disposal of rubbish. Western culture has been described as the "throw-away society" and the use of packaging and disposable items has increased tremendously in the past 30 years. Local councils have been given the job of disposal of rubbish, but in recent years this has become a major problem. This could change, if this rubbish could be seen as a potential source of energy.

The most common way of disposing of rubbish is to put it in a hole in the ground. There are now well defined rules as to how this can be done, as this approach is potentially a source of pollution. The hole has to be carefully made into cells lined with a impermeable membrane of clay or plastic, and each cell capped with a similar membrane However, the rubbish ferments and produces biogas, as anaerobic bacteria begin to work This biogas has been identified as a potential danger, as it can build up and explode However, it can also be tapped off and used as a source of energy, either in furnaces to produce heat for industries such as brick making, or as a fuel for internal combustion engines generating electricity. In 1993, 77 MW of electricity was generated from landfill gas in the UK. There were 95 contracts under the first three NFFO schemes (1990, 1992 and 1994) generating a potential total of 166 MW.

The rest of Europe is behind Britain in the use of landfill gas. There is a keen interest in those countries that use landfill as the main way for the disposal of refuse, such as Germany. However, many nations are looking for more effective ways of using refuse to generate energy.

Urban sewage also uses anaerobic fermentation to generate biogas, which can be used as a source of energy A second source of energy for electricity generation from biomass under NFFO has been sewage gas. 26 contracts were signed for a total of 33 MW under NFFO 1 and 2. Some of the larger British water companies, such as Thames Water, now generate electricity from almost all of their sewage plants.

The third way of obtaining energy from waste is by burning it. Large scale incineration systems designed to burn Municipal Solid Wastes have been one of the largest sources of energy from biomass contracted under the NFFO scheme in the UK A total of 554 MW from 34 contracts were agreed. The usual approach, called "mass burn", is to put all refuse into the furnace including metals and glass. This means that much of the heat from the furnace is used to produce slag, a molten mixture of non-burnable refuse, which must then be cooled and used for land-fill. A furnace designed to cope with mass-burn must be strong enough to withstand a large metal mass, such as an engine block, being dropped on it, from the rubbish feed system. Another problem with the mass-burn approach is that it tends to produce pollution from strong smelling and often toxic combustion products. Mass-burn incineration is a system which is therefore unpopular with the public

The present emphasis in new schemes involving MSW, is therefore on the separation of refuse into different components There is a very strong move in Europe in general towards recycling, in which glass and metal are removed from the rubbish stream and reused Glass can be remelted and formed into new containers Metals can be recovered and used in alloys for making new products. Even plastics are being melted down and used to make new plastic products, such as fillings for insulation. The removal of these items from the waste stream means that less energy is required to burn the refuse.

A further level of separation removes the wet rubbish, such as food wastes, from the drier components, such as papers and cardboard Wet wastes are difficult to burn, but can be used in an anaerobic digester to produce biogas The dry wastes can be further processed, by densification to produce RDF (Refuse Derived Fuel), which can be used in conventional furnaces, giving a much better heat output. There are several such separation systems in Europe, in countries such as France, Belgium and the Netherlands.

The energy from the biogas can be used to generate electricity from internal combustion engines and the heat from the furnaces can be used as process heat or to generate steam for electricity generation While Britain is behind other nations in Europe in the anaerobic digestion of wet wastes, there is now a plant being built in Scunthorpe, which uses batch type digesters with a high total solids content to deal with these wastes

The most effective way to separate wastes into different streams is at source. In several countries in Europe, domestic rubbish collection now involves different types of rubbish being collected from different bins, often at different times. One bin might contain metal wastes, another glass, another plastic and yet another paper Putrescent refuse (which can be digested) is collected in yet another bin. The influence of the Green parties and that of other environmentalists has meant that most people are prepared to change their habits and to place the different types of rubbish in the correct bins. However, this approach has led to the need for some local government groups to adopt fairly strict means to enforce the correct use of rubbish bins. The concept of the "refuse police" has led to some rather odd court cases in countries such as Germany and the Netherlands.

The processing of industrial wastes to energy is somewhat easier than that of MSW, if there is a large enough quantity of a single type of waste that can be clearly categorised. The use of chicken litter being combusted in a steam raising plant is one such example. There are now two such plants in the UK, one generating 15 MW in Suffolk, another now producing 13.5 MW in Humberside. In Europe, poultry for eating are often raised in large sheds that use wood chips on the floor. The wood chips absorb the chicken droppings and reduce smell and the danger of infection, but their disposal is difficult, as the wood takes time to decompose. These plants are in regions of Britain where local farmers raise large numbers of poultry and are keen to supply the company with used litter, so the cost of fuel is very low Further plants are being planned in Britain and Italy. In total, nn MW were contracted from nn plants that aimed to use this and similar agricultural and industrial wastes under the first three NFFO rounds in the UK.

Another agricultural waste that has a very high potential for energy production is cattle dung. However, the economics of biogas digestion seem to prevent its uptake in a large way in Europe, especially in UK There are farms in Denmark, France, Belgium and Holland using biogas plants to produce biogas, which is used to generate electricity for on-farm use, but the technology has not caught on in a big way. The main reason seems to be the man-power required to feed the plant and to run the engine European farming is heavily mechanised, as labour costs are high A biogas plant that is automated enough to allow it to run with little supervision becomes very expensive. A plant that is less automated, though, costs a lot to run. The low ambient temperatures in Europe also work against the economics of biogas systems. An effective plant needs to be heavily insulated and heated, which puts up the capital cost of a farm-size unit.

There is a growing interest in the use of biogas plants on a much larger scale to drive centralised electric generators that can produce 1 MW or more. The slurry would need to be loaded onto trucks to be transported from the farm to the central unit, but the costs involved seem to be lower than that of running separate farm-scale units

The Use of Energy Crops in UK and Europe

The area that attracts the keenest interest in Europe is the use of energy crops. European farmers are becoming frustrated with the Common Agricultural Policy (CAP) of the EU that restricts the amount of food crops that can be grown, so as to keep the price of food within Europe reasonably high. Food in Europe is subsidised, but if the production is excessive, too much money is required from the subsidies to pay for it. The result has been excessive amounts of stored food. Recent rules have restricted food production, so that these large excesses have been reduced, but at the cost of removing large amounts of land into “set-aside” from agricultural usage. Farmers argue that the growing of fuel crops would help reduce the amount of carbon dioxide produced by using fossil fuels, while using their “set aside” land for the purpose for which it was intended.

The two crops capable of providing liquid fuels for use in transport are vegetable oil and sugar crops, which can be fermented to give ethanol While the economics of these fuels look fairly weak, given the present price of fossil oil, many countries are keen to support a technology that could allow them to continue to supply transport fuels, even if fossil oil prices did suddenly jump Many European countries are concerned that they are dependant on Middle Eastern nations for the supply of oil and would prefer to have the capability of an alternative, even if it might cost more.

Austria and France both have strong programmes developing the use of rape seed oil for fuel The oil is esterified with ethanol or methanol to reduced its viscosity and make it more like diesel, so it can be used in normal diesel engines Rape seed is a crop that grows well in temperate climates and many European farmers are experienced in growing it for food purposes. Although rape methyl ester (RME) costs twice as much to produce as diesel fuel, subsidies and taxes are used to ensure the prices to the customer is equal. Other European countries, such as Italy and Ireland, are also setting up programmes.

One of the most attractive crops for farmers is short rotation coppice (src). Some strains of a temperate tree species, the willow (salix), grows fairly fast, once it has been cut back after the first year of growth. Rather than growing as a single trunk, it throws up many thinner shoots which have a high productivity, up to 18 dry tonnes per hectare. An average growth rate is closer to 12 dtph, as the high growth rate strains tend to be susceptible to disease and pests. Once the root system of a src plantation is established, the shoots can be cut every three to four years and they will regrow again at the same rate. It is thought that a stand could last at least 20 years before replanting and could be cut for up to 50 years without loss of production.

Other tree species can be used for src, such as poplar and hazel, although they may need to be cut at longer intervals to get good growth. Such a plantation can be fertilised by sewerage, as there is no problem with pollutants such as heavy metals entering the food chain. The shoots are normally cut during the cold season, as the species are deciduous and the shoots dry out and loose their leaves. This can be a problem in places where the ground is very wet, as it can be difficult to get heavy vehicles onto such ground

When the sticks are harvested, they are usually about 5 mm in diameter The sticks are usually chopped into chips about 5 mm long, using saws or heavy blades. The sticks can be cut and bundled in the field, where they are air dried before being collected and chipped ready for use Alternatively, they can be chipped during a single pass harvesting process and stored a chips. While the second approach is cheaper for the farmer, it means the wood must be stored and dried in chip form. The chips can be transported in standard trailers can moved between trailers and storage using standard grain lifts.

The use of chips for energy is an area receiving much investigation in Europe at present. The chips can be burn in small standard furnaces for heat production or for steam raising. Such plants are available commercially and used in countries such as Sweden and Finland, where there is a strong timber industry. However, the use of wood chips to raise steam for electricity production is considered uneconomic, as the price paid for the chips is much higher than that paid for refuse or coal.

The most effective and efficient way of using wood for electricity production would seem to be via the gasification route, where the gas is used to drive internal combustion gas engines or gas turbines. Downdraft fixed bed gasifiers are commercially available in Europe that can be used, but the technology is limited to about 200 kW electrical This is too small to be considered a commercial size in the European context, although some farmers and small wood businesses are using them in countries such as France, Spain and Greece.

Updraft fixed bed gasifiers can be made to a much larger size, but the gas from such gasifiers tends to be contaminated by too much tar for it to be easily cleaned for use in an internal combustion engine. Commercial plants of up to 10 MW heat are being used in Finland, but only for driving gas furnaces for heat generation, as the problem of gas clean-up has not been overcome. There are several approaches being made in the area of cleaning tars from the gas from updraft gasifiers. Technology is available from the oil industry for cracking the heavy oils in tars, either thermally or catalytically, but an effective economic system is not yet available. If a solution can be found to this problem, there is a huge potential market for 1 to 10 MW electric generation from biomass

Most of the European effort is now directed towards fluidised bed gasification of biomass. There are several manufacturers of different designs of fluidised bed systems in different European countries, especially Germany, Italy and Sweden, as well as many more prototype systems in different research groups The technology has been proved to work well, generating a clean gas that can be used in either internal combustion engines or in gas turbines. The major drawback, at present, is the relatively high cost of the system. Most analysts suggest that a fluidised-bed gasification system should be used to generate at least 30 MW electricity, using a combined-cycle gas turbine system, to be commercially and economically viable Several such systems are in the planning stage, including one in the North of England under a NFFO contract.

There is a disadvantage of such a large-scale system, as large quantities of wood are required to keep it running Where dedicated plantations of src or other forestry crops are used, or where there are large forestry processing plants, such as in Finland, Sweden, Norway and in some parts of Germany, then transport costs can be fairly low. However, when local farmers are using their set-aside land for growing src, the amount of wood available in a locality would be limited and wood would need to be transported longer distances to supply such a plant. Given that a transport distance is 25 km is acceptable, a typical gasification plant for a European situation should be of a size that will generate 5 MW electrical. This suggests that more development should be done on updraft gasifiers to allow them to produce gas suitable for use in internal combustion gas engines.

Conclusions

Biomass has been an important source of energy for Europe and the UK in the past and could well be an important source of energy in the future.

Energy from waste, especially MSW, is an important area for most European nations and there are several processes that are being used commercially on a large-scale, such as land-fill gas, sewage gas and incineration. These processes could be very much improved if the refuse was properly separated into different streams, either at source or within the process

Energy from biomass crops is another area in which there is strong interest in many European countries. Even though present fossil oil prices mean that liquid fuels from biomass cannot compete on price, concerns about security of supply mean that programmes to manufacture and distribute such fuels are being set up in several nations

Electricity generation from solid biomass, such as forestry residues and src, does look reasonably attractive, if the wood is gasified and used in internal combustion engines or gas-turbines Unfortunately the present designs of gasifier seem only to be economic if used at a scale larger than is practical in most situations in Europe. The development of an updraft gasifier that could be used economically and effectively at a scale of between 1 and 10 MW seems to be a very high priority

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Framework for Biomass Energy Technology Promotion in Mountain Areas

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Paper to be Presented at International Conference on Biomass Energy Systems
Jointly Organized by
Tata Energy Research Institute (TERI)
and
British Council Division, New Delhi
February 26-27, 1996 at New Delhi

Abstract

This paper briefly provides a review of the current energy situation in countries of the Hindu-Kush Himalayan Region and discusses the existing energy supply demand imbalances, energy and environmental linkages, and the implication of mountain specificities for and on the energy sector. Given these backdrops, the author attempts to provide a framework for the promotion of biomass energy technologies in mountain areas. The main components of the framework identified and elaborated with the case example of biomass stoves are : I) Matching energy needs, technologies and energy resources; ii) factors promoting technical and economic acceptability; iii) factors promoting socio-cultural acceptability; and iv) Creating a conducive institutional and policy atmosphere.

1. BACKGROUND

The economies of the Hindu Kush Himalaya (HKH) Region[1] are characterized by low levels of development reflected in poverty and heavy dependence on biomass energy The levels of income and development differ within HKH Region as the strategy adopted for economic growth in each country is different and the level of natural resource endowment and the patterns of energy consumption and energy resource mix varies greatly

Though the level of resource endowment and energy consumption pattern varies significantly the region exhibits growing environmental stress Natural resources, specifically forest and water, are threatened by the food and energy needs of the growing population represented by subsistence economic conditions evident in the increasing rate of deforestation (ADB and ICIMOD 1992)

1.1. Background of Countries of the Hindu-Kush Himalayan Region

The countries of the HKH Region (here-in-after referred to as Region) have a total population of 2365 million, of which more than five percent live in the mountains The average population density in the region amounts to 154 persons per square kilometer, while it is 36 within the HKH Region There is substantial variation in the population density in the HKH region within countries, i.e , 130 in Nepal and 12 in China Table 1 summarizes selected development indicators in the countries of the region

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[1] The 3500 km of mountain range that stretches from Afghanistan in the west through Pakistan, India, China, Nepal, Bhutan, Bangladesh to Myanmar in the east is home to more than 120 million people (ICIMOD 1995a)

Against the infant mortality rate of 60 per 1000 births for the entire world, it varies between 31 to 129 in the region There are significant variations within the region with China and Myanmar having a higher Human Development Index (HI) whereas low level of literacy and a high percentage of poverty are reflective of the poor quality of life for a major part of the population. There are also variations within the countries and within the HKH area[2]

A large majority of the population remains without access to safe water, or adequate health facilities poverty levels are high and as per the UNDP report on Human Development (1994), out of the total poor of 1175 million in the entire world, the Region has 625 million and most of these fall within the HKH area Though economic growth and development has improved living conditions, the HKH area remains one of poorest in the world Figures 1 to 4 present the various development indicators

2. REVIEW OF CURRENT ENERGY SITUATION IN THE REGION

2.1. Existing Energy Consumption and Supply Pattern

The total final energy consumption amounted to 71311 Million GJ in the Region in 1992, out of which 66% was met by commercial energies and the rest was met by traditional fuels, though large variation in the share of traditional fuels is observed For example, in countries like Afghanistan, Bhutan, Nepal and Myanmar the share of traditional fuels lies between 75% and 95%, while in countries like China and Pakistan it is less than 25% as shown in Table 2. Big countries like China and India consumed about 66% and 29% of the total energy, respectively, while the remaining countries consumed less than 5%

There is also a wide variation in the per capita final energy consumption pattern within the countries For example, in India and China it is 2-3 times more than the average value amounting to 16500 MJ per capita. while it varies between 7500 and 16500 MJ per capita in the other countries This has been a consequence of various socio-economic factors besides the availability of energy resources and reliable technologies

Given the unreliability of estimates of total energy consumption in the HKH area the energy consumption pattern in the domestic sector -- as seen from various case studies -- shows that the contribution of traditional fuels amounts to more than 90% of the total energy requirement except in Jammu and Kashmir (Table 3) The share of fuelwood in traditional energy exceeds 65% except in the Ningnan County of China The trend indicates that the use of agriculture residue and animal dung as a source of energy is on the rise in the HKH Region, but in urban areas the transition from biomass to commercial energy forms is at a slow pace This can be safely attributed to the slow rate of growth of economic activities due to the prevailing development barriers

The energy resource base of the Region incorporates a combination of traditional and commercial sources including fuelwood, agriculture residue, animal wastes, hydroelectricity, and petroleum, coal, wind and solar The energy potential in the countries of region is presented in Table 4 The present sustainable supply of energy amounts to more than 6 times the total energy consumption

The resources available in the Region vary significantly For example, the share of coal occupies first place with more than 90% in China and India, whereas, renewable energy accounts for less than 2% in China and 6% in India, 8% in Bangladesh and 11% in Pakistan In Afghanistan and Myanmar sustainable supply of renewable energy amounts to 26% and 20% respectively, while it is 100% in countries like Bhutan and Nepal Though reliable estimates of the energy resource availability of the HKH area is not available, the trend of resource availability as depicted in countries like Nepal prevails in the HKH area In Nepal and Bhutan, hydropower typically occupies first place with more than 60% share, while biomass constitutes 4% in Bhutan and 10% in Nepal The present usage pattern shows that biomass contributes more than 90% in meeting the current energy needs while hydropower contributes less than 1 percent

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[2] For example, one of the district of Nepal, Kathmandu has HI of 0 4

Almost 94% of the sustainable supply is available in the form of coal --mostly in China and India Only about 60% of the total final energy demand of the countries in Region can be met by sustainable supply of renewable energy assuming a loss of 50% during conversion of primary energy into final energy

If India and China were to be excluded from the analysis then the sustainable final energy supply potential would exceed 3 7 times the total final energy demand assuming the overall conversion efficiency of 50% between primary and final energy supply

It is interesting that if 70% of the present energy demand is assumed to be met by biomass fuels in countries other than India and China then only about 35% of this demand can be met by biomass fuels with the remaining having to be met by other means This scenario is likely to represent the prevailing energy supply pattern in the HKH Region

2.2. Energy Use and Human Development

Scrutiny of the relationships between HI, adult literacy, infant mortality and GNP per capita of the countries of the Region shows strong correlation with some variations (Figure 5) These variations could be attributed to the policies and implementation strategies of respective governments and are indicative of how economic growth is tied with equity concerns and the governments' expenditure on social sector At this point, it is interesting to note that on regional terms the average HI, adult literacy, infant mortality and GNP per capita are well balanced and the countries of the region seem to be doing quite well Unfortunately, a closer look at the condition of the HKH Region with HI of about 0 1 indicates an increasing disparity among the people of the HKH Region as against the rest of the population in the countries of the HKH Region

The relationship as represented in Figure 6 prompts us to state that the increased level of final energy consumption is a manifestation of the economic progress and better quality of life of the nation (Philips et al 1995) However, close observation between energy consumption per capita, HI, industrialization ratio, and urbanization ratio among the countries of the Region clearly reflects that the relationship depicted in Figure 6 does not completely hold true, as substantial variation is observed in Figure 7 This means that the level of energy consumption alone does not necessarily imply a desired level of human development, rather it means that there is a need to re-orient energy development paradigm to one that suits the requirements and aspirations of the people of the HKH Region

3. CHALLENGES IN THE DEVELOPMENT OF ENERGY SECTOR

3.1. Energy Supply and Demand Imbalance

The HKH Region is faced by a severe imbalance of sustainable energy supply and demand as discussed earlier This is due to the fact that the development of renewable energy requires a large initial investment which, however, comes out to be cheaper in the long run The economic cost of biomass fuels is rarely perceived by either the users or the nations and thus the traditional sources of energy still play a dominating role at the cost of the resource being degraded at a rate faster than it can be replenished

The present trend of unsustainable and indiscriminate use of biomass resources has affected the welfare of the population in the HKH Region as it raises the time committed in collecting fuelwood and fodder. It has likewise reduced the productivity of farms and adversely affected the quality of life (Monga et. al 1988, Monga et al 1992)

Lack of adequate, reliable and affordable supply of energy in mountain areas, particularly for cooking, heating and lighting, is a major constraint to the socio-economic development and improvement in the quality of rural life (Dhar et al 1987)

Some of the common factors responsible for the poor performance of the energy sector in the HKH Region are: centralized planning with supply-oriented approach, lack of sufficient trained manpower, lack of standardization of equipment, distorted pricing structures, political pressure to sell commercial energy at less than cost-price, lack of R&D support for renewable energy development, etc (Ramani et al 1995, Munasinghe et al 1989, Goldemberg et al 1988)

3.2. Energy and Environmental Linkage: Global Concerns

The production and use of energy contributes negatively to the environment It is widely believed that if the present trend of energy consumption continues, it will create environmental problems which in the long run could become a constraint for economic growth and social well-being

Globally recognized as most prominent is the problem of greenhouse gases Carbon dioxide, methane and nitrous oxide, the main greenhouse gases, are emitted mainly from combustion of fossil fuels, deforestation and biomass burning Energy is estimated to account for more than 50% of the global greenhouse gases (PEP Project 1995) The energy related emission in the HKH Region is modest if estimated at regional level, but it is rising at an alarming rate in urban areas of the HKH Region Illustrating this phenomena are urban centers like Kathmandu and Dehradhun which have already become one of the most polluted places in the Region in terms of fossil-fuel-related emissions The emission of greenhouse gases caused by deforestation and biomass burning is bound to increase in the HKH Region in the event of the economic transformation foreseen for poverty elimination and development of the mountain population as it would mean an increase in the demand for useful energy (i e., heat, light, and shaft power)

Population growth is putting extreme pressure on the region's forest resources contributing to landslides, soil erosion and flooding, thereby endangering the lives of thousands of people every year Further more, the possibility of substituting fuelwood by commercial fuels in mountain areas of the HKH Region are limited mainly because of two reasons First, fuelwood collection is a subsistence type of non-monetized activity - it is free if the labour cost is not considered Second, the cost of distribution of commercial fuel is very high Unless the cost of fuelwood rises considerably due to physical or economic scarcity this situation is not expected to change, the rural population, where per capita income is less than US $ 100, cannot afford to use modern fuels

The intricate relationship which exists between energy - economy - environment is understood generally However, a lack of knowledge to capture the dynamic linkage among these sectors continues due to weak data base and analytical capability

3.3. Environmental, Health and Poverty Linkages

A particular concern is the health impact associated with the household use of traditional fuels This issue has important linkages to the gender and generational aspects The majority of the people, especially women and children are seriously affected by exposure to very high concentrations of emissions resulting from cooking with low-grade fuels, and with stoves and in poorly ventilated environments (deLucia 1993, Rijal 1994) The energy system transformation that reduces the health risks as well as poverty must be promoted

4. MOUNTAIN SPECIFICITIES FOR AND IMPLICATIONS ON THE ENERGY SECTOR

Box 1 shows the numerous implications created by the mountain specifics (Sharma 1994a, Jodha and Shrestha 1994, Banskota and Sharma 1992, Rijal 1996) on and for the energy sector

Box 1 : Mountain Specificities and Implications on and for Biomass Energy Sector

Mountain Specificities	Primary Attributes	Adaptation Characteristics	Implication on Energy Sector	Implication for Energy Sector
Inaccessibility	Isolation, High cost of supply system Limited access, Invisibility of problems	Multiple use of resources and technologies	Interventions failed due to sectoral Approach	Better understanding of sectoral links, i e, fuel, fodder, and food chain
Fragility	Resource highly vulnerable to rapid deforestation, Low productivity & resources Disperse settlement	High community participation, People's oriented problem solving, Integrated farming system Prevailing barter system	High costs of interventions, Higher level of energy input	Augment in Energy supply; Improve efficiency of conversion
Marginality	Limited resources and productivity, minimal consideration of areas/people	Exploitation of potentials by core areas/population, use of marginal areas by others dependency	Destruction at margin process	Encourage forest management to provide fodder fuel & timber
	Subsistence economy	low risk taking capability	slow pace of dissemination	link energy and income generation
Diversity	Diverse resource and approach environmental situation Large-scale micro-variations in physical/biological attributes, Interdependence of production bases	multiple cropping diversified up-land low-land farming systems	increase in energy inputs, increased dependency on a specific fuel	adopt need-base approach and diversify fuel use
Niche	Small-scale specialization Location and Area specific comparative advantage Location Specificity of Production and consumption	Emphasis on activities that are mostly of an extractive nature logging hydroelectricity	Decentralized energy system preferable	Indigenous technical knowledge-base for maintaining forest areas, traditional water wheels

Source Banskota and Jodha (1992), Sharma and Banskota (1992), Sharma (1994), Jodha and Shrestha (1994) PEP (1994), Rijal (1996)

Inaccessibility induces isolation which means high cost of energy supply system, that in turn, forces local residents to modify their needs to what they have

Fragility reflects the vulnerability of energy resources The decrease in productivity and low resource capability results in diverse settlements and consequently, the supply of energy infrastructure system which would mean high cost.

Marginality means that energy resources may be exploited by people living near the available resources and the rapid process of destruction at the margin becomes a visible phenomenon promoting extensive use of marginal areas by people without easy access to the resources Furthermore, people residing in the mountains have a marginal say in the development process as the cost of not doing anything for the mountain people does not affect the power equation Thus it remains outside the major development negotiations and subsequently energy technology interventions

Diversity means that the cost of extraction of energy resources in usable form is high and because of the diverse nature the realization of economy of scale is not feasible In order to negate the economy of scale particular resources and technologies tend to be used for multiple applications

Given all these facts, the positive implication would be to capitalize on the diversity of the available energy resources for specific purposes by minimizing the constraints imposed by the mountain specificities The positive outlook would be to capture the opportunities generated by the mountain specific characteristics rather than harping on the constraints

5. CONCEPTUAL FRAMEWORK FOR TECHNOLOGY PROMOTION: A CASE EXAMPLE OF BIOMASS STOVES

A basic feature of the HKH Region is the majority of the population that lives in the countryside, quite removed from the amenities of modern cities and towns These people are forced to lead simple lives, extracting virtually all their energy requirements from their environment The price of this energy self-sufficiency, particularly for the poor and specifically the women and children, can be quite enormous in terms of human efforts This tedious and arduous labour is aggravated by the low efficiency of end-use devices As a result

biomass is the principle fuel for cooking and space heating,
animate energy is the main source of mechanical energy,
domestic sector is the main consumer of energy, and
cooking and space heating are the dominant end-uses

The objective of the energy system is to provide energy services Energy services are the desired and useful products, processes, or services that result from the use of energy - for instance illumination, cooking, space conditioning, etc The energy chain that delivers these services begins with the collection or extraction of primary energy, which is then converted into energy carriers that are suitable for the end-uses These energy carriers are used in end-use devices to provide the desired energy services as presented in Figure 8

Noteworthy is the fact that it is useful energy which determines the extent of fulfillment of energy needs and improvement in the physical quality of life Therefore, better efficiency of energy use permits significant improvements in the physical quality of life without increase, or even with decrease, in the amount of primary energy while at the same time it reduces the release of environmental affluent (Codoni et al 1995) Also, when a particular energy carrier is used efficiently or shift is made into more efficient energy carriers then inefficiently used sources will be available for alternative uses (Goldemberg 1988) For example, large scale dissemination of improved cookstove may possibly allow animal dung to be used as farm-yard manure

5.1. Misleading Perception: Problem of Diagnosis

In the rural mountain areas, more than 90% of the total energy required is for domestic activities The energy services in domestic activities are primarily for cooking, space heating and lighting On account of primary energy supply, cooking requires almost 70-80% of the total energy whereas space heating accounts for less than 25% From energy services point of view, however, useful energy required for space heating exceeds 60% while useful energy required for cooking amounts to 25-40% in mountain communities (Rijal 1991, PEP 1995, Islam 1984) Substantial variation on space heating requirement depends on the climatic condition of a specific location, building envelope, energy resources and the technologies employed The exact variations are not yet properly understood

During the early 80's awareness of wood-fuel crisis resulted in a proliferation of technologies Improved cookstoves were conceived to reduce the fuelwood consumption level These efforts were also initiated in mountain areas of HKH Almost all community forestry as well as energy programs initiated in the hills and mountain communities had major components of improved cookstoves claiming to save 25-35% of fuelwood consumption (CFDP 1984, Islam 1984, Pradhan & Rijal 1988)

The cue for crisis was dictated in the developed world and technological interventions were conceived there without properly understanding the needs of the local community and little room was left for the developing nations to understand and modify program components to suit their needs In a hurry to improve the efficiency for cooking, a major end-use for mountain communities -- space heating -- was forgotten Also, multiple uses of resources and technologies was always neglected, this being a common phenomenon in the subsistance economy of mountains

Fuelwood was believed to be needed primarily for cooking and its requirement in space heating was not given due consideration Most of the technologists were only concerned with the pot utilization efficiency (PUE) for cooking and the suggested technological interventions considered PUE as a guiding principle

The traditional supply oriented approaches of meeting the energy needs of mountain population are the main causes of the ICS program failures Though there are other reasons i) adequate consideration was not given to the religious, cultural and ethnic background, ii) target group identified for imparting information and training was faulty, iii) efficient technology was distributed in areas where fuelwood was still easily available at no price, iv) dissemination programmes were not carried out through the right kind of agencies and institutions, and v) the felt-need of the people was not taken into account (Rijal 1987, PEP 1995, Rijal 1991)

5.2. Matching Energy Needs, Technologies and Energy Resources

The objective of the energy system is to provide energy services Energy services are the desired and useful products, processes, or services that result from the use of energy - space heating and cooking The energy chain that delivers these services begins with the collection or extraction of primary energy (forest), which is then converted into energy carriers that are suitable for end-uses These energy carriers (primary energy - fuelwood, secondary energy - charcoal) are used in end-use devices (stoves used for space heating and cooking) to provide the desired energy services

Choices are available with regard to energy resources and technologies The choice of particular resources and technologies primarily depends on parameters such as availability of energy resources and technologies, prices, life of the device, efficiency of the device However, the selection of a particular energy resource and technology is not only dictated by technical parameter but also by social and cultural acceptability of the technologies

Matching energy needs with energy systems is in itself a complex process and should be viewed as an integral part of the matching process In general, the following steps should be considered for matching energy needs with decentralized energy system (Ashworth and Neuendorffer 1982)

Step 1: Understanding the Socio-economic and Spatial Dimension
The selection process must be based on the area's socio-economic circumstances and spatial dimensions The social needs of the mountain communities desires that the fire place/space heating devices be located at the centre of the house as it facilitates greater interaction among the family members of the mountain communities Similarly, mountain specific conditions such as inaccessibility demands the use of low-grade indigenous fuels (i e , biomass) rather than the use of commercial fuels such as kerosene

Step 2: Identification of Energy Needs
The next step is to determine which needs are of prime importance to the mountain population and what particular activities require energy Continuous consultation with the communities is essential to prevent the imposition of outside biases. Too often energy planners autonomously decide what is needed for the people i e , cooking needs forgetting the space heating If the mountain communities do not play a significant role in selecting what needs must be met first, they are not likely to actively support the technology introduction processes, assist in any necessary modifications, or maintain the energy system

Step 3: Screening of Technological Options
Once the energy needs are defined, the process of narrowing down the range of technological options should begin The preliminary screening of energy systems is the first component of actual matching of needs and technologies The important characteristics of each energy need are identified and compared with the characteristics of each available unit to determine how the system fits the energy need The preliminary screening employ a set of criteria relating to energy needs These are i) type of energy output required, ii) temperature of energy required, and iii) spatial distribution required The first criterion selects those technologies that provide the energy form required to meet the need without energy transformation The second criterion identifies energy systems that produce a sufficient level of thermal or kinetic energy to perform the task The third criterion addresses the problem of providing energy where it is required For example, if energy must be delivered to several sites, the technological options selected should be such that energy supplies either can be moved efficiently and easily or can be located at each site

Step 4: Matching Technologies with the Needs and Resource Base
This steps should provide the data on energy needs and energy systems that determine their compatibility in a particular location Together with the mountain communities, energy technologists should evaluate the local resources The energy resource base should be evaluated on the following criteria i) physical availability, ii) variability, and iii) constraints on use The first criterion determines the size of the resource base and current demands upon the resource The second criterion explains the changes in the resources on a daily, seasonal and annual basis The third criterion clarifies with regard to ownership of resources, cultural and/or economic restrictions on use, and conflicting use of the same resources

An Illustrative example of matching process with regard to cooking and space heating requirement is shown in Box 2

Box 2
An Illustration of Matching Process: Cooking and Space Heating Requirement

Key characterization criteria

- Temperature of output,
- Time of day of output;
- Socio-cultural (with specific emphasis on gender), and
- Environmental criteria

Best matches with need

- Biomass,
- Passive Solar, and
- Building Orientation and Insulation

Other possible matches

- Micro-hydro (electric),
- Kerosene; and
- Diesel (electric)

Advantages of best-match technologies

- No energy transformation required;
- Biomass energy systems do not depend directly on climate variations. easily stored and eliminates the need to store output energy, biomass combustion is most acceptable and convenient technology. answer for shortages of fuelwood may be to introduce more efficient space heating technology or to accelerate biomass production through plantation,
- Proper building orientation will increase heat flow inside the house.
- Insulation will reduce the heat losses from the building envelope

Problems with other possible energy sources

- Electricity is a high-grade energy and is most undesirable to be used for heat application,
- High cost of transporting kerosene and diesel,
- Conversion inefficiencies

5.3. Framework for Technology Diffusion

Technology in Context: Biomass Stoves

Successful diffusion of stoves depends upon understanding how the mountain people are accustomed to organizing their productive activities and regulating their social relationships as these relate to mountain specificities (Brulez and Linder 1984, Dhar 1994, Soussan, Shrestha and Uprety 1995) It is into this sociocultural context that efficient space heating technologies must be introduced If they do not fit, they will not be diffused, regardless of their technological promise

Many of the mountain population meet most of their cooking and heating needs, outside the money economy Most of the rural households still intend to maintain self-sufficiency within their own community if not within the household However, money and markets are becoming more important Cash is required to meet a growing number of needs, including the that for energy technologies

Many productive relationships among the mountain people are still structured by kinship and castism The introduction of stoves designed to utilize biomass energy more efficiently and that cost money must take mountain realities into account

The issue of equity also becomes critical as the mountain people do not enjoy the type of access to energy resources and technologies as their counter-parts in the plains This issue is not important as long as biomass resources is available in abundance But as the biomass resources start diminishing the need for adopting efficient technologies demands a higher level of cash expenditure on energy commodities At the same time, production base is gradually decreasing with increase in the population and also physical limits imposed by mountain specificities These factors need to be given due consideration while designing framework for the diffusion of stove programmes.

The socio-cultural aspects of diffusion of biomass stoves are of particular importance where the adopters of the technology lie mainly outside the cash economy For them, adoption of biomass stoves is governed by a more complex mixture of factors

Factors that Promotes Technical and Economic Acceptability

Review of various literatures (Rijal 1995, NRC 1984, CFDP 1984, Clarke and Shrestha 1987) shows that several factors appear to enhance technical and economic acceptability of biomass-based renewable energy innovations with respect to mountain communities and would equally apply diffusion of biomass stoves These are

Structural Simplicity and Scale Simplicity facilitates the acquisition and maintenance of technologies It also lessens the risk of dependence on external support for operation, repair and maintenance and minimises the need for extensive capital investment For example, The Lorena Stove, developed in highland Guatemala in the mid-1970's and widely diffused in both rural and urban Honduras, has this virtue (Clarke 1985)

Use of Familiar Materials Employing familiar materials wherever possible enhances technological acceptability by lessening the requirement for learning Use of local materials and craftmanships will also increase diffusion For example, the mud-chimney stoves that are being popularized in Nepal are gaining some momentum as this stove primarily uses local materials and craftmanships

Employment of Familiar Technique If the techniques for designing, manufacturing and operating are familiar, the advantage is clear Reliance on these methods minimizes the need for special training and for external supervision For example, the recent introduction of back boilers with the chimney stoves are being readily adopted by the people of Ghandruk (Banskota and Sharma 1996)

Integration with Existing Technology The economic advantages of an innovation that fits readily into an existing technological management system are evident This integration minimizes the capital and/or labour costs of adopting traditional production patterns to meet the requirements of efficient biomass stoves For example, introduction of efficient biomass stoves integrated with traditional methods of food preparation, fuel collection and storage will enhance chances of acceptance Where such integration is lacking, there is a risk that the stove will be modified by users for better technological "fit" in ways that diminish its efficiency

Factors that Promotes Socio-cultural Acceptability

The following conditions in general appear to increase chances for socio-cultural acceptability with regard to biomass stoves (Clarke and Shrestha 1987, Clarke 1985, Islam 1984, NRC 1984, Pradhan & Rijal 1988, Rijal 1987), though these variables will have to be accessed in the context of each local culture into which they have to be introduced

Compatibility with the Existing Work Organization . An understanding of indigenous systems of work organization is important to the successful diffusion of efficient biomass stoves For example, where firewood collection and food preparation are women's work and stove construction is categorized as a male prerogative, motivation to accept efficient biomass stoves may be lacking (Rijal et al 1987)

Reasonable Cost of Technology To foster diffusion, the system of distribution must allow for the disposition of the efficient biomass stoves at a cost that most people can meet For example, more localized the manufacture and distribution of stoves, the more widespread their diffusion is likely to be, since they can be better adopted to meet local conditions

Integration with Social Structure Compatibility with the existing social structure -- family organization, system of stratification based on caste, ethnicity, gender - is also a factor in winning acceptance and ensuring diffusion of biomass stoves For example, the relationship of efficient biomass stove diffusion to the social structure is exemplified by the problem resulting from women's traditionally sub-ordinate social status as male decision makers give women's needs lower priority Thus technology diffusion should target the women community

Accommodation to Authority Understanding the local political system - the organization for making and enforcing community-wide decisions, settling disputes, and regulating relations with neighbouring people -- and how it relates to the biomass stove programme will enhance the chances of adoption For only when local decision-making processes are understood, and those with true authority are identified, can effective plans be made to ensure popular local participation and acceptance

5.4. Creating a Conducive Institutitonal and Policy Atmosphere

Institutional Atmosphere

Some institutional issues are worth mentioning A decentralized approach to energy planning and its distribution is a viable alternative approach to centralized energy system Decentralized approach here means going beyond the district to the villages through users groups improved biomass stove program can be successfully implementated in a variety of institutional setting Many NGO based programs may be more flexible, committed and closer to usres Sustainable institutional setting in the long run, however, should come through participatory institutions at the grassroots level (Banskota & Rijal 1996)

A decentralised-user group approach also appears neccessary from the transmission cost point of view For a wider mountain community in remote and inaccessible parts it may take many more years before their villages can be linked to the national grid system Centralised system from a cost effectiveness point of view tends to rely on relatively large scale energy production units, e g hydro electric production, which in poor countries are often at the mercy of external capital This raises serious doubts on developing an effective and efficient energy planning framework Greater relience on user group based systems may prove to be more sustainable (Banskota & Rijal 1996)

Policy Atmosphere

In the first place energy policy must emphasize renewable sources which implies that in the case of mountain areas of HKH two options are available, namely, firewood and electricity The promotion of energy efficiency (both technical and allocative) should receive priority in designing energy policy Distorted pricing regulation is always detrimental to the promotion of efficient energy use as it causes faulty, inefficient fuel uses and gives wrong investment signals to consumers. In conjuction with programs to increase energy efficiency, programs should be implemented to sustain the supply of traditional fuel through improved management of forest and plantation programs which requires strong grassroots institutions In other words, conservation interventions should strike a realistic balance between sustainable supply and demand management This requires not only an integrated environment cum economic policy and program but also an effective institutional framework from the national to the grassroot levels (Banskota & Rijal 1996)

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Table 1: Development Indicators of the Countries of the HKH Region

Descriptions	Population in Millions 1992	Area Th. Sq Km. 1992	People in Ab Poverty % 1992	Adult Literacy % 1992	Infant Mort. (per 1000 birth) 1992	GNP per Capita US $ 1992	HDI Index 1992	Indutrializa-tion Ratio % 1992	Urbaniza-tion Ratio % 1992	Pop without Access to Health % 1992	Pop without Access to Water % 1992
Afghanistan	21 5	652 2	47	29			0 21			46	71
- HKH only	14 5	390 5									
Bhutan	1 5	46 5		38	129	180	0 15	36	6	33	73
- HKH only	1 5	46 5									
Bangladesh	114 4	144 0	81	35	91	220	0 31	26	18	42	
- HKH only	1 2	13 2									
China	1162 2	9581 0	9	73	31	470	0 65	34	27	10	18
- HKH only	19 9	1647 7									
India	883 6	3287 3	40	48	79	310	0 38	44	26		
- HKH only	37 3	482 9									
Myanmar	43 7	677 0	35	81	72	230	0 41	17	25	52	69
- HKH only	5 9	280 9									
Nepal	19 1	147 2	65	26	99	170	0 29	26	12		62
- HKH only	19 1	147 2									
Pakistan	119 3	796 0	29	35	95	420	0 39	45	33	11	55
- HKH only	23 2	404 2									
Regional Average			26	59	56	384	0 51	37	26	9	14
Regional Total	2365 3	15331 2									
HKH Average											
HKH Total	122 6	3413 0									

Source
1 Statistical Abstract - INDIA (1984) Central Statistical Organization, Ministry of Planning, GOI, India (1985)
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10 Pakistan Statistical Yearbook 1992 & 93 Federal Bureau of Statistic Govt of Pakistan (1993)
11 Statistical Yearbook of Nepal - 1993 Central Bureau of Statistics National Planning Commission, Kathmandu (1993)

Table 2: Energy Consumption Pattern in the Countries of HKH Region, 1992

Energy Forms	Units	Afghanistan	Bhutan	Bangladesh	China	India	Myanmar	Nepal	Pakistan	Total
Hard Coal	'000 MT	8	[illegible]	338	1090809	240405	34	92	4222	1335926
Coke	'000 MT	0	[illegible]	0	78999	10800	10	0	737	90546
Lignite	'000 MT	0	[illegible]	0	0	16560	39	0	0	16599
Fuelwood	000 M3	19852	[illegible]	7900	611295	549347	22358	15569	[illegible]	[illegible]
Ag & Animal Residue	'000 MT	1985	[illegible]	29033	339820	376303	360	2425	[illegible]	[illegible]
LPG	'000 MT	0	4	8	3508	2760	4	6	151	6441
Motor Gasolene	'000 MT	82	3	106	25753	3762	121	19	1131	30977
Kerosene	'000 MT	10	[illegible]	424	4322	9597	[illegible]	97	507	15073
Jet Fuel	'000 MT	83		24		1100	19	19	431	1676
Diesel	'000 MT	125	15	1042	35290	24430	272	147	5026	66347
Fuel Oil	'000 MT	2	[illegible]	444	34545	10050	115	10	3298	48464
Natural Gas	[illegible]	7373	[illegible]	195306	614720	455760	37950	0	467310	1778419
Electricity	Million kWh	834	[illegible]	9554	758920	329340	2674	926	51972	[illegible]
Thermal		225	[illegible]	8758	[illegible]	251285	1395	61	30365	[illegible]
Hydro		478	[illegible]	796	132470	69848	1279	870	[illegible]	[illegible]
Nuclear						6748			425	7173
Geothermal						32				32
Import		131	3		4980	1500		80		6694
Export			1425			73		85		1583

Final Energy Consumption Pattern

Units 000 GJ

	Afghanistan	Bhutan	Bangladesh	China	India	Myanmar	Nepal	Pakistan	Total
Biomass Fuels	257282	[illegible]	458240	11433882	11168770	[illegible]	212709	335536	[illegible]
Petroleum Products	13606	[illegible]	94502	4801950	2392089	[illegible]	13719	[illegible]	[illegible]
Natural Gas	7373	0	195306	614720	455760	37950	0	467310	[illegible]
Coal	202	[illegible]	8518	29858357	6680286	1859	2318	128504	[illegible]
Electricity - Renewables	2192	[illegible]	2866	494820	280998	4604	3114	75625	[illegible]
Total	280655	[illegible]	759431	47203729	20977902	335550	231850	1496779	[illegible]
Traditional Energies	257282	[illegible]	458240	11433882	11168770	[illegible]	212709	335536	[illegible]
Commercial Energies	23373	[illegible]	301192	35769847	9809133	69421	19151	1161243	[illegible]

Units MJ per Capita

	Afghanistan	Bhutan	Bangladesh	China	India	Myanmar	Nepal	Pakistan	Total
Biomass Fuels	11945	[illegible]	4006	9838	12640	6090	11160	2813	9204
Petroleum Products	632	[illegible]	826	4132	2707	572	720	4106	[illegible]
Natural Gas	342	0	1707	529	516	868	0	3917	985
Coal	9	302	74	25691	7560	43	122	1077	4360
Electricity - Renewables	102	[illegible]	25	426	318	105	163	634	275
Total	13031	[illegible]	6638	40616	23741	7676	12165	12546	16641
Traditional Energies	11945	[illegible]	4006	9838	12640	6090	11160	2813	9204
Commercial Energies	1085	[illegible]	2633	30778	11101	1589	1005	9734	7437

Unit % of total

	Afghanistan	Bhutan	Bangladesh	China	India	Myanmar	Nepal	Pakistan	Total
Biomass Fuels	91.7%	[illegible]	60.3%	24.2%	53.2%	79.3%	91.7%	22.4%	33.9%
Petroleum Products	4.8%	[illegible]	12.4%	10.2%	11.4%	7.5%	5.9%	32.7%	[illegible]
Natural Gas	2.6%	[illegible]	25.7%	1.3%	2.2%	11.3%	0.0%	31.2%	[illegible]
Coal	0.1%	[illegible]	1.1%	63.3%	31.8%	0.6%	1.0%	8.6%	51.4%
Electricity - Renewables	0.8%	[illegible]	0.4%	1.0%	1.3%	1.4%	1.3%	5.1%	1.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Traditional Energies	91.7%	[illegible]	60.3%	24.2%	53.2%	79.3%	91.7%	22.4%	33.9%
Commercial Energies	8.3%	[illegible]	39.7%	75.8%	46.8%	20.7%	8.3%	77.6%	66.1%

Note 1/ includes hydro nuclear and geothermal

Source 1 Energy Statistics Year book 1990 1991 1992 United Nations (1994)
2 Energy Indicators of Developing Member Countries of ADB ADB Manilla (1992)

Table 3a: Per Capita Final Energy Consumption in the Domestic Sector of HKH Region

Descriptions	Fuelwood	Agric Residue	Animal Dung	Biogas	Total Biomass	Kerosene	Electricity	Coal	LPG	Total Commercial	Total
Natural Unit per Capit	Kg	Kg	Kg	MJ		lit	kWh	Kg	Kg		
Nepal	450	164	105	0		8	12	0	0		
- Mountain	657	75	121	0		2	5	0	0		
- Hills	527	172	7	0		6	11	0	0		
- Terai	354	174	178	0		10	14	0	0		
India											
- Jammu & Kashmir	392	33	248	0		26	136	0	0		
- Himachal	874	198	59	0		8	106	0	0		
- Uttarakhand (U P)	577	87	0	0		6	19	0	0		
- Sikkim	447	52	0	0		12	7	0	0		
- North-eastern States	547	181	0	0		13	38	0	0		
- West Bengal	527	172	7	0		6	11	0	0		
Bhutan	1848	0	0	0		6	9	0	0		
China											
- Ningnan County	358	402	0	44		3	16	15	0		
Pakistan											
- Swat District	719	20	12	0		6	62	0	19		

Source
1 Energy Environment and Sustainable Development in the Himalayas ed Monga P and Ramana P V , Indus Publishing Company, New Delhi (1992)
2 Himalayan Energy Systems ed Dhar T N and Sharma P N Gyanodaya Prakashan Nainital India (1987)
3 Energy Planning and Management in Kulu District India MIT Series No 4, ICIMOD Kathmandu (1991)
4 Energy Planning and Management in Almora District India MIT Series No 3 ICIMOD Kathmandu (1991)
5 Energy Planning and Management in Dhading District Nepal MIT Series No 5 ICIMOD Kathmandu (1991)
6 Energy Planning and Management in Swat District Pakistan MIT Series No 6 ICIMOD Kathmandu (1991)
7 Energy Planning and Management in Ningnan County China MIT Series No 2 ICIMOD Kathmandu (1991)
8 Energy Planning and Management in Mountain Districts Bhutan MIT Series No 1 ICIMOD Kathmandu (1991)
9 Energy Sector Synopsis Report Water & Energy Commission Secretariat Kathmandu (1995)
10 Perspective Energy Plan for Nepal NPC/UNDP National Execution Project Kathmandu (1995)

Table 3b: Per Capita Final Energy Consumption in the Domestic Sector of HKH Region

Descriptions	Fuelwood	Agric Residue	Animal Dung	Biogas	Total Biomass	Kerosene	Electricity	Coal	LPG	Total Commercial	Total
Unit MJ per Capita											
Nepal	7522	2071	1140	0	10733	286	43	0	0	329	11062
	68%	19%	10%	0%	97%	3%	0%	0%	0%	3%	100%
- Mountain	10979	947	1317	0	13242	58	17	0	0	75	13317
	82%	7%	10%	0%	99%	0%	0%	0%	0%	1%	100%
- Hills	8803	2167	81	0	11050	217	38	0	0	255	11305
	78%	19%	1%	0%	98%	2%	0%	0%	0%	2%	100%
- Terai	5912	2191	1941	0	10044	380	52	0	0	432	10476
	56%	21%	19%	0%	96%	4%	0%	0%	0%	4%	100%
India											
- Jammu & Kashmir	6542	412	2703	0	9657	957	490	0	0	1446	11103
	59%	4%	24%	0%	87%	9%	4%	0%	0%	13%	100%
- Himachal	14591	2501	646	0	17737	288	382	0	0	670	18407
	79%	14%	4%	0%	96%	2%	2%	0%	0%	4%	100%
- Uttarakhand (U P)	9635	1096	0	0	10731	228	70	0	0	298	11029
	87%	10%	0%	0%	97%	2%	1%	0%	0%	3%	100%
- Sikkim	7457	651	0	0	8109	420	26	0	0	446	8555
	87%	8%	0%	0%	95%	5%	0%	0%	0%	5%	100%
- North-eastern States	9131	2282	0	0	11413	456	137	0	0	593	12006
	76%	19%	0%	0%	95%	4%	1%	0%	0%	5%	100%
- West Bengal	8803	2167	81	0	11050	217	38	0	0	255	11305
	78%	19%	1%	0%	98%	2%	0%	0%	0%	2%	100%
Bhutan	30862	0	0	0	30862	227	33	0	0	259	31121
	99%	0%	0%	0%	99%	1%	0%	0%	0%	1%	100%
China											
- Ningnan County	5979	5071	0	44	11094	117	58	376	0	551	11645
	51%	44%	0%	0%	95%	1%	1%	3%	0%	5%	100%
Pakistan											
- Swat District	12001	254	131	0	12386	218	223	0	563	1004	13389
	90%	2%	1%	0%	93%	2%	2%	0%	4%	7%	100%

Source Table 3a

Table 4: Energy Resource Base in the Countries of the HKH Region

Energy Forms	Unit	Afghanistan	Bhutan	Bangladesh	China	India	Myanmar	Nepal	Pakistan	Total
Coal	000 MT	112000		1054000	286400000	131254000	5000		28590	418853590
Oil	000 MT			4983	3264000	810000	7000		28826	4114809
Natural Gas	Mil. m3	100000		360000	1127000	730000	265000	5	728000	3310005
Uranium	MW					10000			10000	20000
Peat	000 MT			138000	4687000	10571167			0	15396167
Geothermal	MWh									0
Hydro	MW		20000	1400	335000	150000	20000	83000	30000	639400
Wind	MW					20823		15	2642	23480
Wave	MWh									0
Biomass	000 MT	15882	1382	34563	767726	760845	16011	13323	22729	1632460
Solar	MW	130400	9400	28800	1912200	657600	127953	26649	159200	3052202
Note	a/- sufficient for 10000 MW development									
Coal	Mil GJ	2822	0	26561	7217280	3307601	126	0	720	10555110
Oil	Mil GJ	0	0	229	150144	37260	322	0	1326	189281
Natural Gas	Mil GJ	3600	0	12960	40572	26280	9540	0	26208	119160
Uranium	Mil GJ	0	0	0	0	158	0	0	158	315
Peat	Mil GJ	0	0	2484	84366	190281	0	0	0	277131
Geothermal	Mil GJ	0	0	0	0	0	0	0	0	0
Hydro	Mil GJ	0	315	22	5282	2365	315	1309	473	10082
Wind	Mil GJ	0	0	0	0	328	0	0	42	370
Wave	Mil GJ	0	0	0	0	0	0	0	0	0
Biomass	Mil GJ	233	20	506	11247	11146	235	195	333	23916
Average Insolation	Mil GJ	2056	148	454	30152	10369	2018	420	2510	48127
Total	Mil GJ	8711	484	43217	7539043	3585788	12555	1925	31770	11223493
		0%	0%	0%	67%	32%	0%	0%	0%	100%
Renewable	Mil GJ	2289	484	983	46681	24209	2567	1924	3358	82495
		3%	1%	1%	57%	29%	3%	2%	4%	100%
Non-renewable	Mil GJ	6422	0	42234	7492362	3581579	9988	0	28412	11140998
		0%	0%	0%	67%	32%	0%	0%	0%	100%
										Average
Yearly Supply Potential	MJ/Capita	112232	322545	15972	169100	108013	63324	100964	32910	115633
		1 0	2 8	0 1	1 5	0 9	0 5	0 9	0 3	1 0
Renewable		106269	322545	8589	40166	27398	58752	100964	28147	86604
		1 2	3 7	0 1	0 5	0 3	0 7	1 2	0 3	1 0
Non-renewable #/		5964	0	7384	128934	80615	4571	0	4763	29029
		0 2	0 0	0 3	4 4	2 8	0 2	0 0	0 2	1 0
Energy Density	GJ/sq. km	3707	10294	12689	20555	29027	4088	13648	4932	12368
		0 3	0 8	1 0	1 7	2.3	0 3	1 1	0 4	1 0
Renewable		3510	10294	6823	4882	7363	3792	13648	4219	6816
		0 5	1 5	1 0	0 7	1 1	0 6	2 0	0 6	1 0
Non-renewable #/		197	0	5866	15673	21664	295	0	714	5551
		0 0	0 0	1 1	2 8	3 9	0 1	0 0	0 1	1 0

Note · #/- Non-renewables being consumed within 50 yrs

Source 1 Energy Statistics Year book 1990, 1991, 1992, United Nations (1994)
2 Energy Indicators of Developing Member Countries of ADB, ADB, Manilla (1992)

Figure 1

Human Development Index in the Countries of the Region

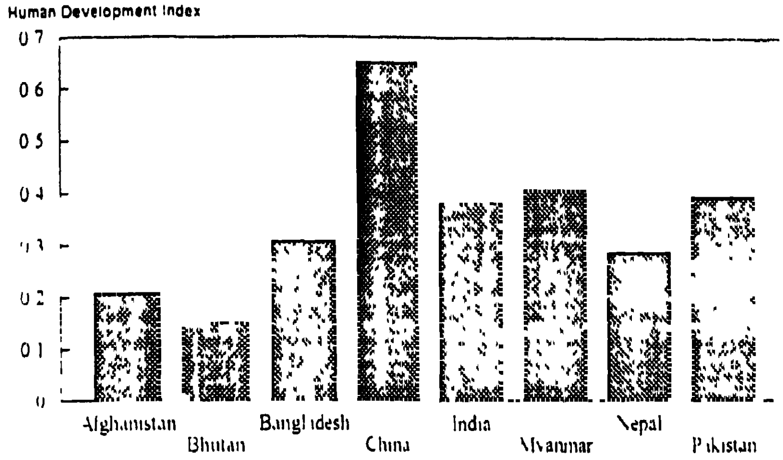


Figure 2

Percent of Adult Illiteracy in the Countries of the HKH Region

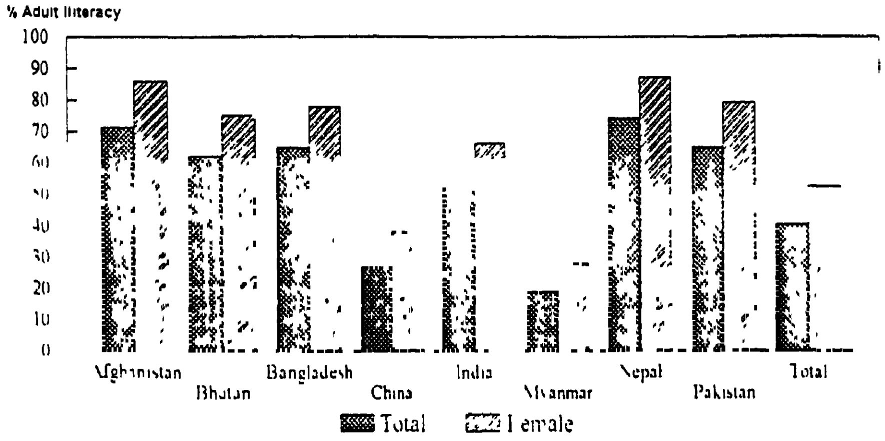


Figure 3

People in Absolute Poverty in the Countries of the HKH Region

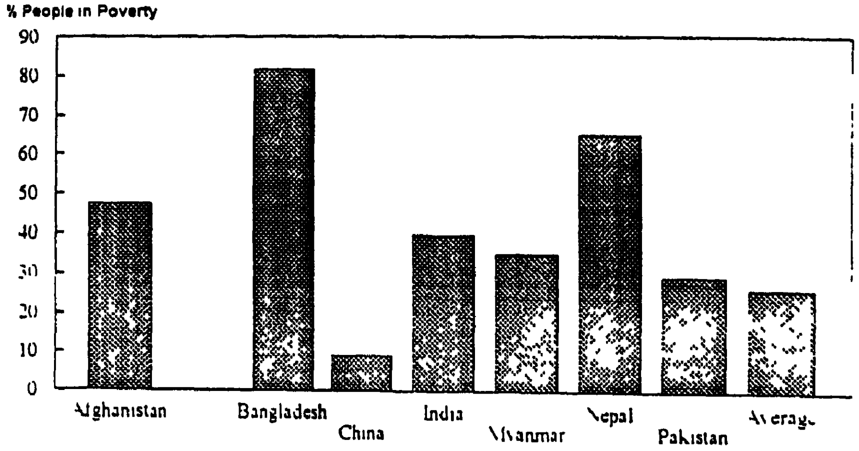


Figure 4

People without Access to Health Services in the Countries of the HKH Region

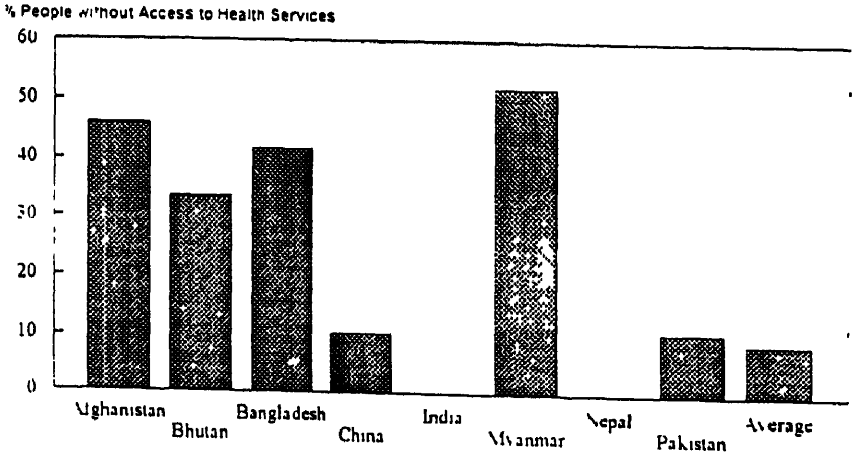
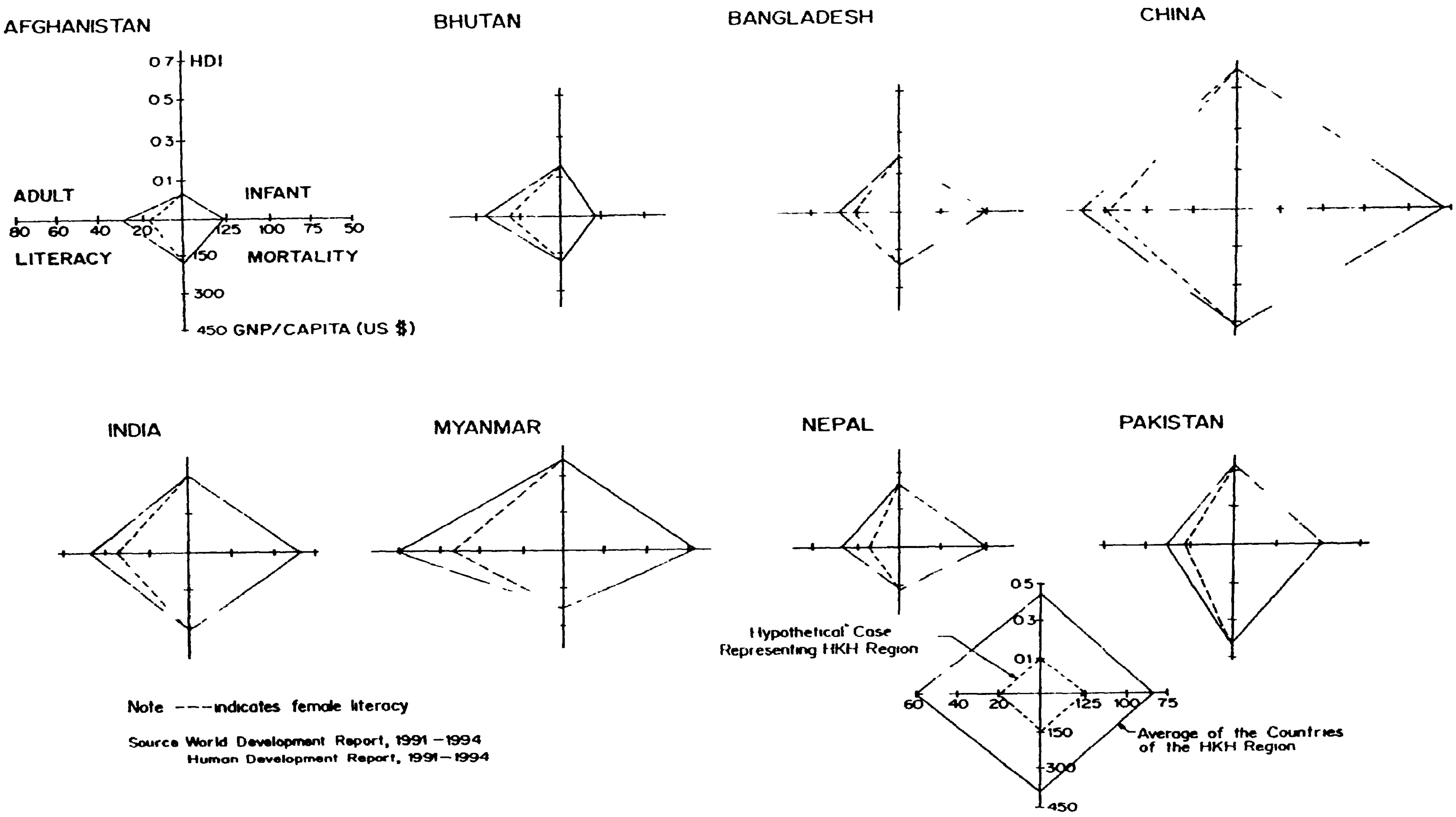


Figure 5

HUMAN DEVELOPMENT INDICATORS IN THE COUNTRIES OF HKH REGION

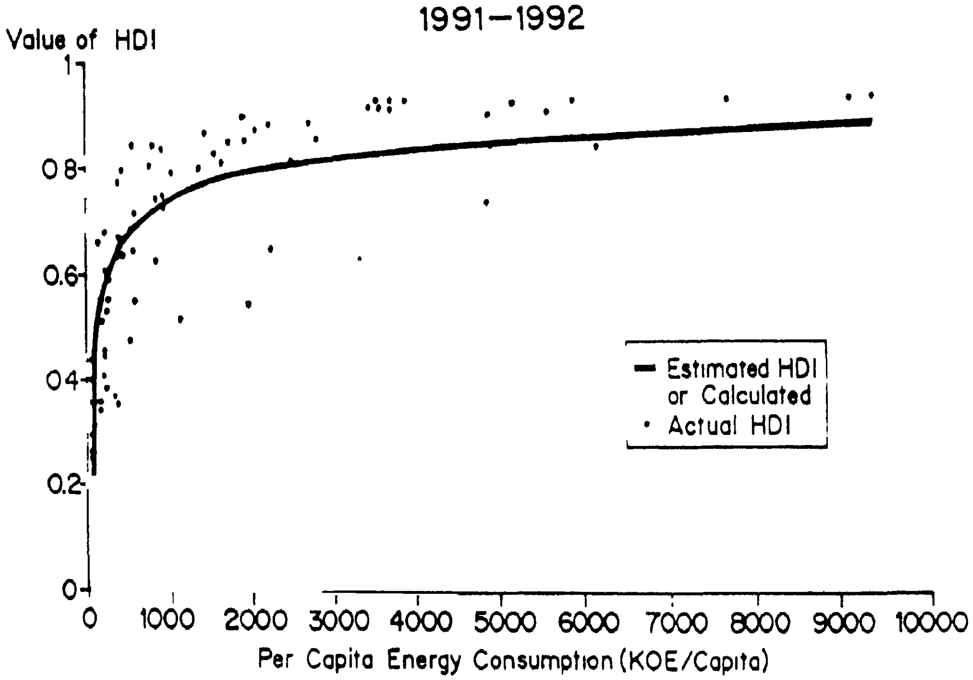


Note ---indicates female literacy

Source World Development Report, 1991 – 1994
Human Development Report, 1991 – 1994

Figure 6

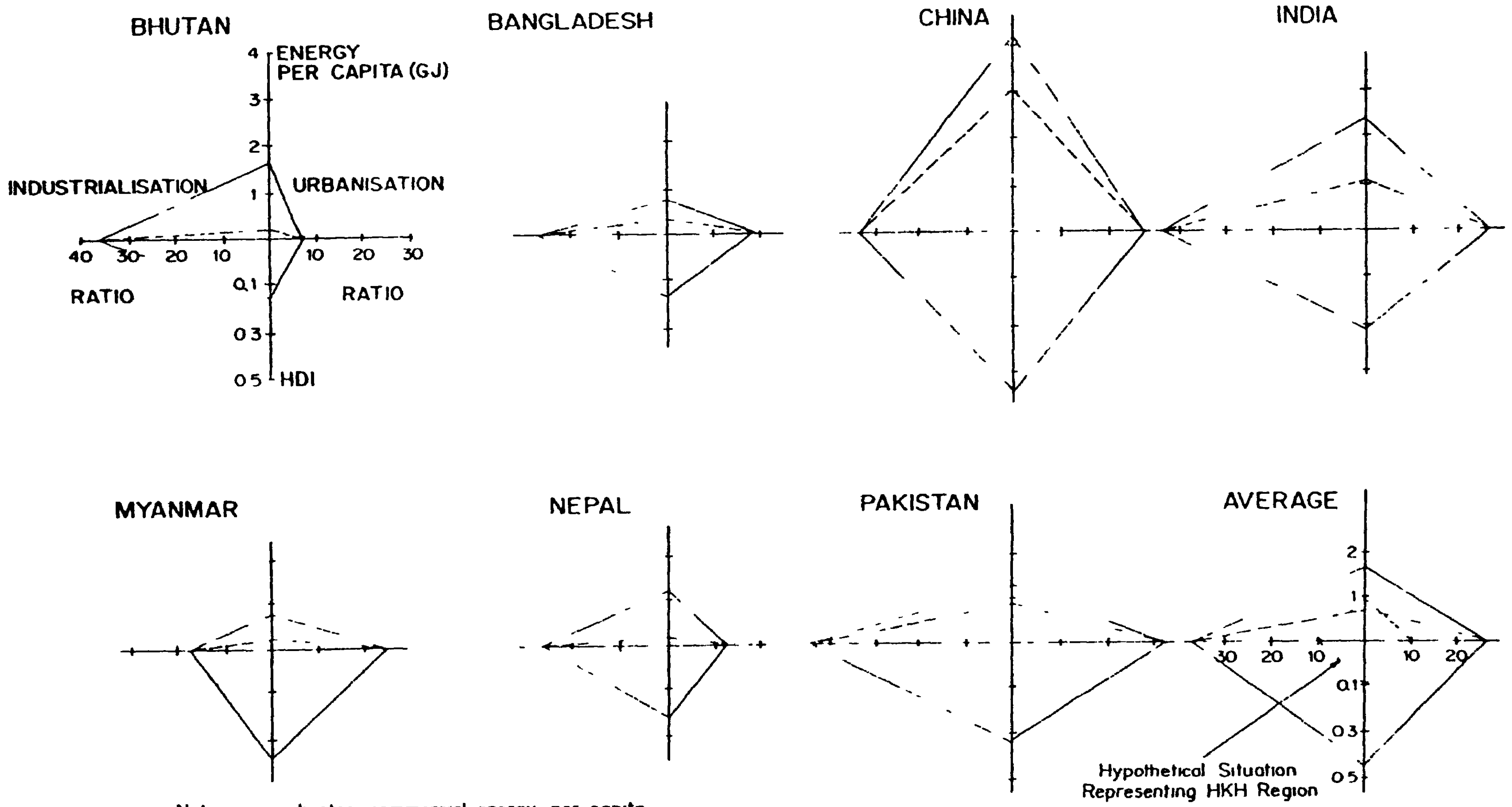
Estimated Relationship Between HDI and Per Capita Energy Consumption
1991–1992



Note Data for 100 developed and developing countries

Source. Philips, R, Goldemberg, J and Johansson, T B, Energy as an Instrument for Socioeconomic Development, UNDP (1995)

ENERGY CONSUMPTION PATTERN AND SOCIOECONOMIC VARIABLES

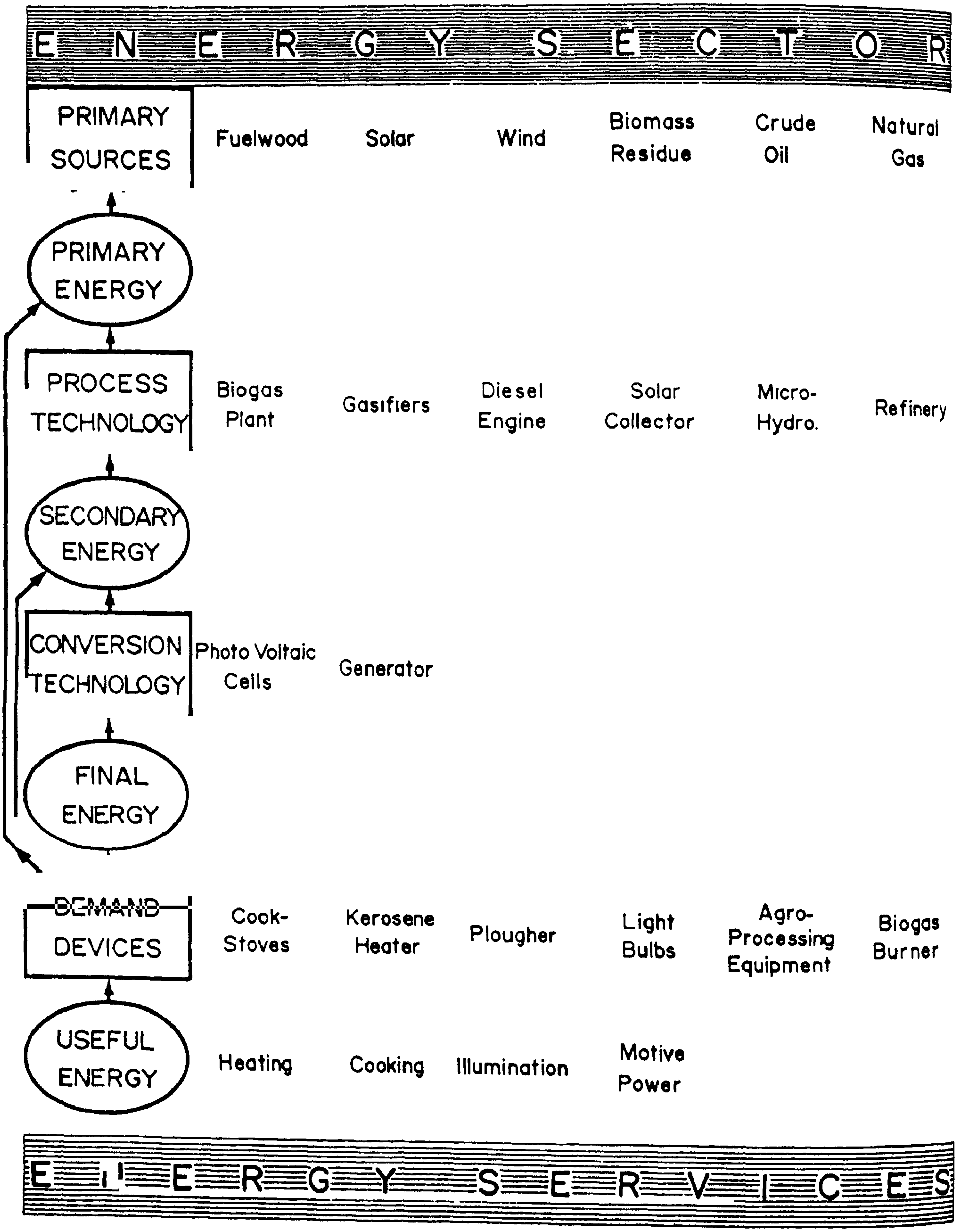


Note ---indicates commercial energy per capita

Source World Development Report, 1991–1994
Human Development Report, 1991–1994
Energy Statistics Year Book, 1990–1994

Figure 8

Conceptual Framework for Reference Energy System



Pollution free utilization of biomass through combustion, carbonization and briquetting of residual char

by

U Tin Win
San San Technological Institute, Myanmar

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"Pollution free Utilization of Biomass through Combustion, Carbonization and Briquetting of Residual Char" by U TIN WIN

Background

The year 1995 was designated as the "Year for substitutional Use of Fuelwood by other Means" in Myanmar by the Government on a National scale Government organisation and NGOS, studied researched and disseminated the use of Biomass energy throughout Myanmar San San Industrial Cooperative was also involved in this venture

In the Dry Zone areas of Upper Middle Myanmar, use of fuelwood was strictly prohibited and intensive dissemination for use of agro and forestry wastes was substituted. Thus biomass energy utilization and production of a variety of biomass stoves, briquettes and briquettors became a popular industry.

My interest started when Dr. Lantin of UNIDO introduced me with designs from IRRI Rice Husk Stoves The use of biomass energy was then intended to control forest depletion.

In 1993, after detail study of parts and its operational methods of a briquetting machine from PRC, I started to build briquettors and produce rice husk briquettes for domestic use In 1995, when Myanmar Government initiated to exhibit biomass energy utilization in lieu of fuelwood and wood charcoal to the public, San San Industrial Cooperatives also participated by displaying its products. Dr W S Hulscher, Chief Technical Advisor of RWEDP, Thailand, also visited the exhibition. It was due to his interest in my endeavours, I was able to attend a International workshop on Biomass Briquetting from April 3 - 6, 1995 at IIT, New Delhi, India During that visit, I also had opportunity to visit Tata Energy Research Institute and IIT Delhi's Biomass Conversion laboratory

When Prof. Dr P D Grover of IIT Delhi visited Myanmar in June, 1995 under arrangements of RWEDP and Myanmar Forest Ministry and FAO Representative (Myanmar), I had the opportunity of attending his talks and obtaining latest technologies of biomass energy

Introduction

Biomass gasification was new to me before Dr P D Grover's introduction My interest was aroused by the Gasifier Stove's (known as Paru Stove) ability that it does not emit dense smoke like direct burning type of biomass stoves during initial light up. Biomass energy use was initially set back in some areas due to this problem Emission of smoke contain pollutants that could effect the environment and health of the users Pollution free utilization of Biomass through combustion, carbonization and Briquetting of Residue Char is basically an extensional development in gasification of Paru Gasifier Stove Paru Stove's burning of agro and forestry residues is carried out indirectly. In the central portion, charcoal/briquetted fuel and refractory stones are added and the annulus volume of the jacket is filled with Biomass

When Charcoal is ignited, heat is transmitted to the biomass through the wall of the central stove and eight fins, provided for efficient heat transfer This biomass on heating emits combustible gases with substantial amount of biomass tar in vapour form. These gases are prevented from coming out of the jacket and only allowed to exit through holes provided at bottom of charcoal bed. When gases come in contact with charcoal and hot stones, the tar vapours, which normally burns with smokey flame, are thermally cracked into clean combustible gases

Top Ignition

The concept of Top Ignition is basically a provision of a Hot carbon Combustion zone in the path of the gases produced when biomass is burned. Any technological development needs constant updating, so biomass combustion in that context is of no exception. Air pollution in big cities has gained wider attention Recently, indoor pollution from domestic biomass combustion has become a matter of serious concern too. Domestic use of biomass is increasing day by day as population grows and other energy sources for heat are not usually within reach of the rural communities in most poor and developing countries. Biomass combustion emits other carbon containing materials besides CO_2. These products of incomplete combustion are also of concern because of their effects on health and global warming potentials. It's effect can be seen in the table below.

Energy

Biomass composes about 14% of all direct human energy use
It is about 33% of energy use in developing countries.
It is about 75% of energy use in rural areas of developing countries.
It is the most important fuel for the majority of humanity.
Sources : Smith (1987) ; Meyers and Leach (1989) ; Hall and Rosillo-Calle (1991)

Health

Cause of up to 50% of total human exposure to RSP
Affects second-largest occupational group (cooks), after farm workers
Known risk factor for most important killer of developing country children (pneumonia)
Source : Smith (1993)

Global warming

Human biofuel consumption : 20 - 40% of all biomass combustion
1 - 5 % of all CH_4 emissions
6 - 14 % of all CO emissions
8 - 24 % of all TNMOC emissions
1 - 3 % of all human-generated global warming
Sources : Smith, Khalil et al. (1993) ; Ahuja (1990)

Currently biomass combustion has only one combustion zone and mainly rely on Oxygen. In a two Layer combustion zone, carbondioxide can be used as base to convert to carbonmonoxide Reaction needs heat and pollution free clean biomass combustion is based on this technology.

My research work has two seperate combustion arrangements of biomass energy. Biomass wastes are ignited in the first combustion and converted to carbondioxide. This is then drawn into second combustion by passing through top of the hot carbon zone, where heat application converts it into carbonmonoxide as producer gas. This producer gas is almost pollution free with high degree of burning capabilities. Residue char can again be made into briquettes for use as fuel.

Layout and Process

The diagrammatic layout is attached with this paper Any biomass can be ignited in the first combustion chamber and converted into carbondioxide. A blower draws out this gas through a gas cleaner and stores it in a damper vessel. A control valve near the Hot Carbon Zone controls the CO_2 which then could pass through top of hot carbon combustion zone where heat converts it into carbonmonoxide as producer gas ready for use by burning. Smokeless, clean blue flame and high temperature is the end result. This is our pollution free technology and wonderful power of carbondioxide utilization

Technical Evaluation

This concept of biomass energy utilization can be of great interest because input biomass can be any type mixed like municipal wastes. Since disposal of municipal wastes throughout the world is of an important nature towards environmental pollution and health problems, use of such wastes as basic fuel for biomass energy generation can become an important issue of the future.

Other uses of this energy generated can be coordinated and experimented as the technology spreads throughout the world

Conclusion

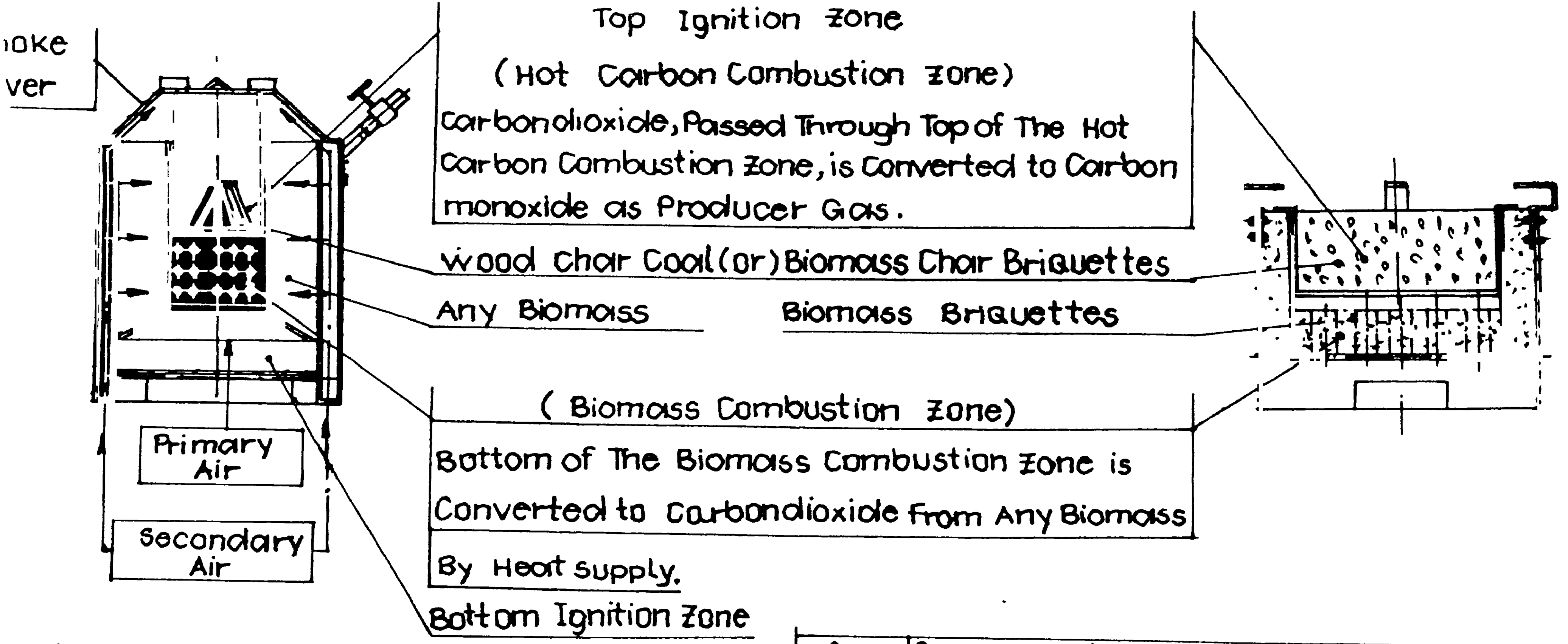
I must take this opportunity to say that I am not an expert on biomass energy but an interested person who is involved in production of biomass stoves, briquettors and briquettes and biomass gasifiers for sale in Myanmar. My presentation may lack the necessary technical and chemical datas of a normal presentation. This limitation is due partly to my limited out of pocket expenses and lack of adequate infrastructure establishments in this biomass context in Myanmar.

However, if my limited research and development contribution could become a corner stone in the Biomass Energy Research and Development of the world nations, I will be indebted to Prof. Dr. P D. Grover of IIT New Delhi who has always inspired and encouraged me in the context of Biomass Energy Technology

Everyone knows how difficult it is to clean up an environment once it is polluted. The problem is whether the cost is affordable and the same applies to development of pollution technology. I am somewhat determined to continue in this pursuit in my own capacity and with possible help from others for creation of a Pollution free world of tomorrow

LLUTION FREE UTILIZATION OF BIOMASS THROUGH COMBUSTION CARBONIZATION AND BRIQUETTING OF RESIDUAL CHAR

(BIOMASS COMBUSTION GAS STOVE)



Top Ignition Zone

(Hot Carbon Combustion Zone)

Carbondioxide, Passed Through Top of The Hot Carbon Combustion Zone, is Converted to Carbon monoxide as Producer Gas.

Wood Char Coal (or) Biomass Char Briquettes

Any Biomass

Biomass Briquettes

(Biomass Combustion Zone)

Bottom of The Biomass Combustion Zone is Converted to Carbondioxide From Any Biomass

By Heat supply.

Bottom Ignition Zone

sic Chemical Reactions of This Biomass Combustion.

ıstem Are:

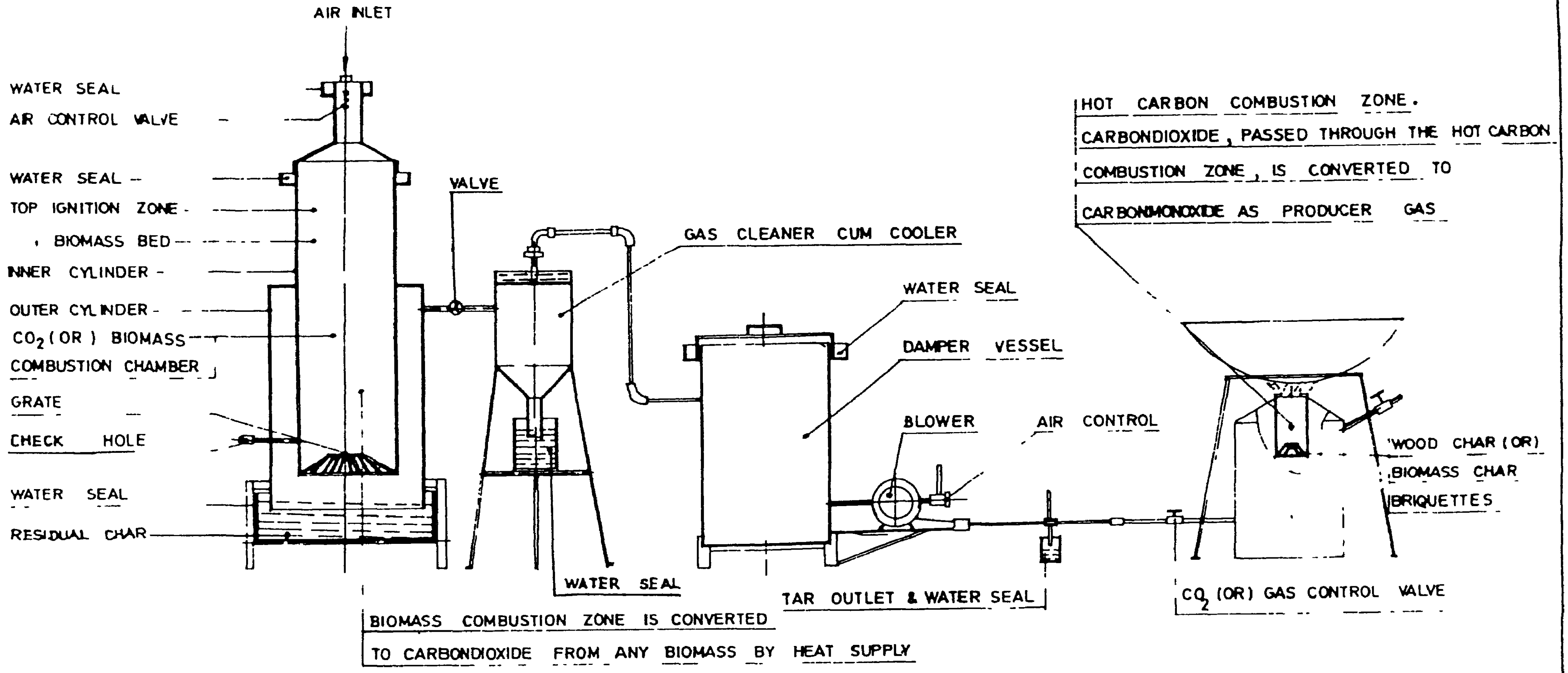
$C+O_2=CO_2$; $CO_2+C=2CO$; $H_2O+C=H_2+CO$; $CO_2+H_2=CO+H_2O$

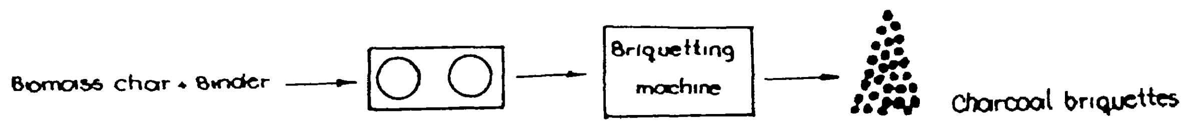
$C+2H_2=CH_4$; etc:-

2	Biomass Container and Combustion Chamber				
1	Smoke Cover and Hot Carbon Combustion Chamber				
Part No.	Nomenclature				
Form A4	Dwn By	Checked By	Approved By	San San Industrial Co; Op, Ltd.	
Name	myo				
Scale	BIOMASS COMBUSTION GAS STOVE			DWG No	Sheet
%				SS [illegible]5 S02	

POLLUTION FREE UTILIZATION OF BIOMASS THROUGH COMBUSTION, CARBONIZATION AND BRIQUETTING OF RESIDUAL CHAR

(FOR INDUSTRIAL USE)

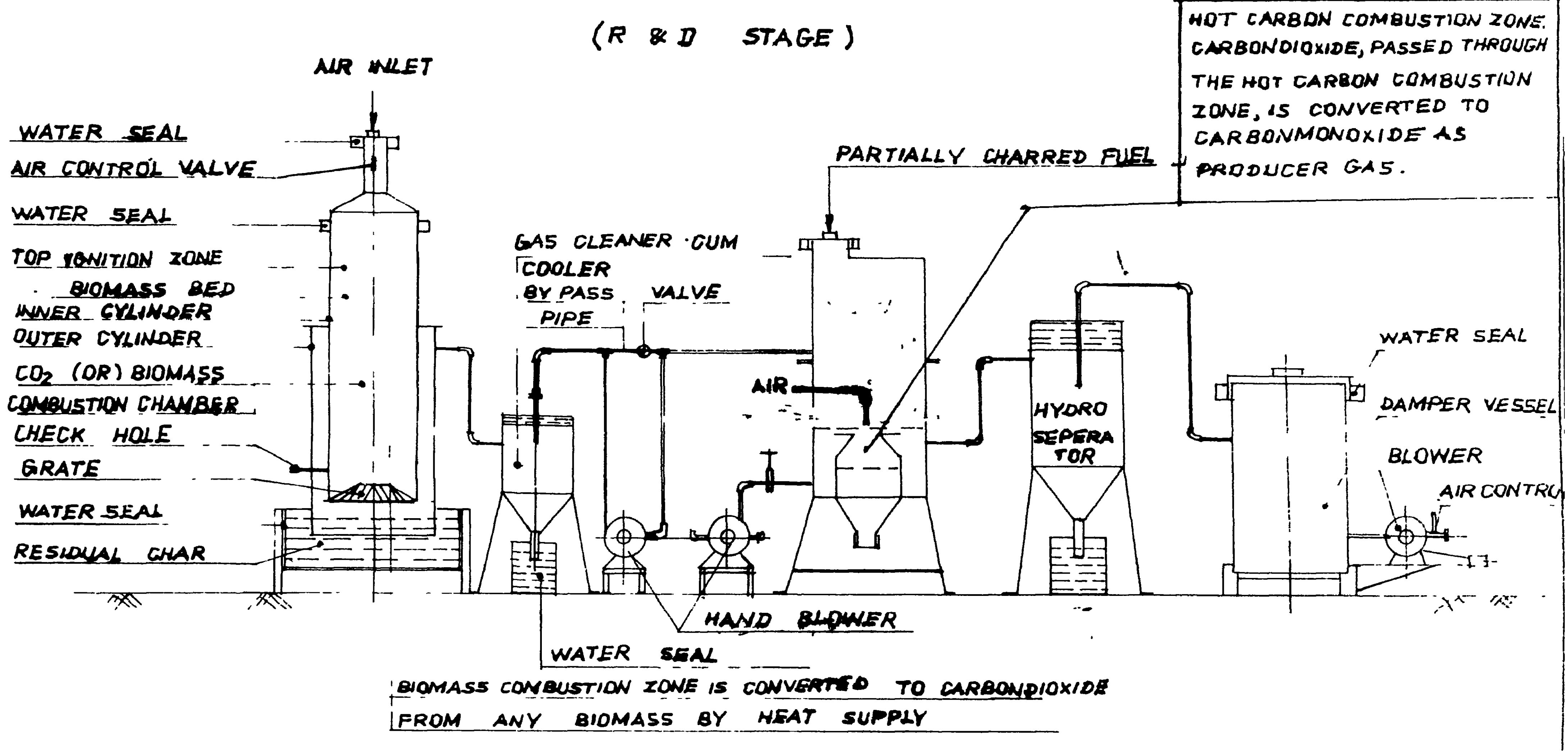

AIR INLET
WATER SEAL
AIR CONTROL VALVE
WATER SEAL
TOP IGNITION ZONE
BIOMASS BED
INNER CYLINDER
OUTER CYLINDER
CO2 (OR) BIOMASS COMBUSTION CHAMBER
GRATE
CHECK HOLE
WATER SEAL
RESIDUAL CHAR
VALVE
GAS CLEANER CUM COOLER
WATER SEAL
WATER SEAL
DAMPER VESSEL
BLOWER
AIR CONTROL
TAR OUTLET & WATER SEAL
BIOMASS COMBUSTION ZONE IS CONVERTED TO CARBONDIOXIDE FROM ANY BIOMASS BY HEAT SUPPLY
HOT CARBON COMBUSTION ZONE.
CARBONDIOXIDE, PASSED THROUGH THE HOT CARBON COMBUSTION ZONE, IS CONVERTED TO CARBONMONOXIDE AS PRODUCER GAS
WOOD CHAR (OR) BIOMASS CHAR BRIQUETTES
CO2 (OR) GAS CONTROL VALVE



FORM A3	DRAWN BY	STD CHKD BY	APPROVED BY	SAN SAN INDUSTRIAL CO OP LTD
NAME				DWG No / SHEET
SCALE	BIOMASS COMBUSTION, CARBONIZATION AND GASIFICATION			
%				

POLLUTION FREE UTILIZATION OF BIOMASS THROUGH COMBUSTION, CARBONIZATION AND BRIQUETTING OF RESIDUAL CHAR FOR INDUSTRIAL USE.

(R & D STAGE)



FORMAT	DRAWN	STD CHKD BY	APPRVD BY	SAN SAN INDUSTRI CO, OP. LTD	
NAME					
SCALE	INDUSTRIAL USE (R & D STAGE)			DWG No	SHEET

Woodfuels under community forestry protection in Orissa, India

by

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Lal Bahadur Shastri, National Academy of Administration,
Mussorie

Woodfuels Under Community Forestry Protection in Orissa, India

N.C.Saxena

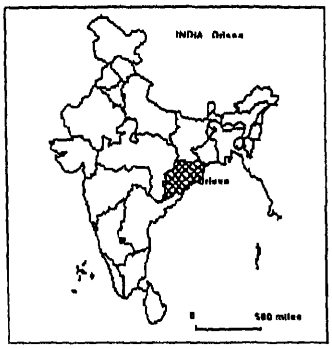
Abstract

Joint Forest Management (JFM) has been promoted in several Indian states under the overall guidance of the Forest Department However, in some parts of India, such as South Bihar and Orissa, a large number of indigenous village groups protecting their common lands have been in existence for several decades prior to the policy of JFM. Such groups have survived with almost no incentive from government This paper, based on author's field work in Orissa, describes the conditions under which local collective action succeeds, institutional arrangement evolved for protection and distribution of produce, equity and gender issues, and the implications of such protection on fuelwood availability Finally the paper examines the constraints of government policy in dealing with such local initiatives

Forests and people in Orissa

Orissa is one of the poorest states of India Its per capita income in 1991 was only Rs 3180 (Rs 32 = 1 US $) as against the all-India average of Rs 4974 Orissa has the highest proportion of population below the poverty line, 45 per cent in 1991, as against the all-India average of 30 per cent Eighty seven per cent of the population lives in rural area, and is dependent on agriculture and gathering from forest lands as the main economic activities Forty per cent of Orissa's population is tribal, whose livelihoods and lifestyles are traditionally associated with forests

In the early sixties the total forest cover in the Orissa State was 43 per cent (6 8 m ha) of the total geographical area By 1991, according to the Forest Survey of India, the forest cover had been reduced to 34 8 per cent (5 6 m ha) Estimates of the degraded forest area vary from 1 to about 3 m ha Sal (*Shorea robusta*) is one of the most important tree species in the State, with a coverage extending over about 1 7 m ha



For administrative and management purposes, the forests in Orissa are divided into Reserve, Protected and Village forests In 1991-92, the total forest area consisted of 47 per cent Reserved (2 61 m ha), 28 per cent Protected (1 57 m ha) and 25 per cent Village forest (1 42 m ha). Reserve forests are fully under the control of the Forest Department and are managed under various silvicultural systems All other forests are included within the village boundaries. In Protected forests, only the forest crop (trees) is managed by the Forest Department, the land is owned and controlled by the Revenue Department Rights and privileges of the local community vary with the type of forest - restricted in Reserved forests and more liberal in Protected forests The village forests are generally treated as open access lands with no investment from government, and are extremely degraded except where community protection has started

Fuelwood[1] situation in Orissa

A wood balance study in 1989 showed that the source of domestic fuel of rural households was as follows -

Table 1: Share of different fuels in rural domestic fuel consumption

source	% share in total consumption
wood and twigs	90 4
animal dung	2 8
leaves	3 7
charcoal	1 1
crop residues	1 5
kerosene	0 5

Reserve and Protected forests were the main source of domestic fuel, accounting for 76 per cent of the fuelwood and 49 per cent of the brushwood (twigs) used Next in importance came village forest, which provided 13 per cent of fuelwood, 32 per cent of brushwood and 15 per cent of dry leaves Most of the latter - 70 per cent - were collected from the roadside

Eighty eight per cent of rural households and 15 per cent of urban households in the state were involved in forestry activities, mainly the collection of forest produce for their own use but also collection for sale The wood balance study estimated that men and women collected forest produce in 149 days in a year Forestry provided 23 per cent of the income of rural households About one third of the households travelled over 5 km for firewood and 2-5 km for brushwood Only small proportions of the materials used by rural households as fuel were purchased (sales are likely to be more to meet urban demand)

Over much of Orissa, the population is finding it increasingly difficult to obtain sufficient supplies of fuel through the traditional means of gathering from the forest However, the extent to which this has occurred varies considerably from area to area within the State With forest sources becoming increasingly distant, people turn to using the stems of lantana, ipericum, ipomia and other shrubs on nearby common and agricultural land, and to such materials as palm fronds, the stalks of such woody stemmed agricultural crops as dal (pulses) and pigeon pea, dry leaves and such non-wood residues as rice and maize stover Those, such as the landless, who do not need it for their fields, also burn dung

The position of the poor needs to be underlined Wood is preferred over many of the substitutes they now use, burning more evenly and with less smoke than most agricultural residues Some of these other fuels are also becoming difficult to obtain, and using them as fuel can have opportunity costs for the user There is therefore no question but that if they could obtain increased supplies of fuelwood it would often improve their situation However, detailed studies elsewhere in India have made it clear that to be useable by them supplies must be available at no financial cost With even minimum food needs usually absorbing all their disposable income, and with the option of shifting to other freely gatherable organic fuels, the poor do not purchase fuelwood

According to the ORG study (1991) domestic cooking constitutes the highest share of firewood consumption in the household sector with an average per capital consumption of 382 kg in rural and 257 kg in urban areas Boiling of paddy is another activity requiring 59 kg of fuelwood per capita in rural areas and 4 8 kg in urban areas Other household activities which require fuelwood are space heating, cattle feed preparation, water heating etc Considering all the domestic activities the annual per capita consumption of fuelwood works out to 523 kg and 285 kg in rural and urban regions respectively Besides, social festivals/ceremonies, space heating in village community centres, cremation of dead bodies are the activities at the community level and consume nearly 3 6 kg of fuelwood per capita per annum The average annual per capita consumption of fuelwood for all the rural artisanal activities (like pottery, blacksmithy, brick making, laundry etc) is around 15 9 kg Besides, commercial establishments, hotels, restaurants, tea shops etc also use fuelwood at 3 7 kg per capita in rural areas and 4.7 kg in urban areas Considering all the activities the per capita consumption of fuelwood in rural areas works out to around 547 kg and 290 kgs in urban areas[2] This would mean a total requirement of about 15 million tonne for the entire population, with an estimated annual increase in demand of 300,000 tonnes or 450,000 million cu m

Estimates for supply are not so reliable The existing forests, estimated at 5 6 million ha together with homesteads and agricultural areas, would produce 15 million tonne if its productivity for fuelwood alone is 2.8 tonne per ha, which, though much above the present level of productivity, is not difficult to achieve Thus the impression created by the Forest Department that forests are put to severe and increasing pressure due to insatiable demand form the people is not valid. The solutions at the macro level have to be sought primarily in increasing the supply of forest products, rather than on demand management Thus constraints of low productivity and poor supply of forest products of the type wanted by the people and livestock, rather than biotic pressure and increased demand, should be of greater interest to a policy maker, if an alternative policy framework to save forests is to be considered

This is not to deny the need for minimising the rate of deforestation and to speed up the afforestation efforts At the same time, there is a need to conserve the consumption of fuelwood in the household sector through technological interventions like use of improved chulas and bio-gas plants

Although trends for Orissa are not available separately, all-India studies show two main trends One change involves the increasing use of modern forms of energy for productive and household activities, including irrigation pumping and lighting A second change is that in some areas rural people, instead of switching up the energy ladder to modern fuels, are switching down the energy ladder to straw, leaves and twigs The use of inferior fuels for cooking by some rural people have implications for their quality of life It is also possible that their general purchasing power has gone down

Since 1985, plantations amounting to some 85,000 hectares have been established on village/ common lands and about 20,000 ha of farm forestry Yield projections show that approximately 2 cu m per hectare can be expected from these plantations annually This means that the project plantations can contribute 170,000 cu m per year towards fuelwood demand Even if the total wood production from such lands were assumed to go for use as fuel, it would not meet more than a third of the estimated annual increase in fuelwood demand But villages are unlikely to use, say, pulpwood grade material as fuel They will probably continue to collect fuelwood from other sources, mainly Reserved and Protected forests, for their own use and for sale, and to sell as much as possible of the out-turn from their woodlots

This underscores the need for producing fuelwood from Reserve and Protected forests through regeneration with people's participation The necessary policy framework for such initiatives has just been evolved in India through Joint Forest Management programmes We first describe government sponsored Social Forestry Programme in Orissa, and then the community inspired protection efforts

Social forestry in Orissa

The social forestry programme of planting woodlots on village lands and distributing seedlings to farmers originated in response to the growing pressure on forests for fuel and fodder needs of the people The National Commission on Agriculture in 1976 recommended growing trees on lands accessible to village people in order to fulfill their subsistence needs, and free the forests to pursue their original objective of producing timber The woodlot programme was based on the premise that the initial investment of afforestation would be undertaken by the government, the plantations being later handed over to the village communities for protection, management and distribution of benefits

The Social Forestry programme in Orissa was funded by the Swedish International Development Agency (SIDA) in two phases, 1983-88 and 1988-94, with a total budget of Rs 270 million and Rs 783 million respectively Out of the 13 districts in the state, the project covered nine in Phase 1 and all in Phase 2 In both phases, the project had four major components -

community oriented

- village woodlots on government wasteland and community land
- reforestation and rehabilitation of degraded and depleted forests

Individual oriented

- farm forestry on private land
- Forest Farming for Rural Poor (FFRP)

Survival - The main activity was establishment of woodlots under the first two components A survey was done in 1992 to study woodlot plantations done from 1984 to 1988 Plantations already recorded by Project as non-productive (less than 30 per cent survival, and which amounted to 32 per cent of the total woodlot area) were not included in the sample Area was categorised as failed if the basal area of trees was less than 3 sq m/ha, and partly non-productive if the basal area was between 3 and 10 sq m/ha Yearwise results were as follows -

Table 2: Survival statistics (area in hectares)

	Year of plantation					total and %
	84	85	86	87	88	84-88
Planted	2196	5501	10697	12470	9955	40819 (100%)
Failed	1125	2053	4049	4624	3349	15300 (37%)
Partly non P	379	1396	2685	2258	2024	8742 (21%)
Net prod	592 (27%)	2052 (37%)	3963 (37%)	5558 (45%)	4582 (46%)	16747 (41%)

Based on the field verifications an average of 37 per cent of the area planted 1984-88 were regarded as failed and another 21 per cent as partly non-productive Older plantations, raised in 1984-85, had a higher percentage of non-productive areas compared to younger plantations The reasons for failures seemed to be combinations of

- * less motivated village communities at the initiation of the plantations, resulting in unsatisfactory protection, grazing and browsing, illicit felling, and in some cases even uprooting of planted seedlings at an early stage
- * climatic conditions (like severe drought)·
- * unfavourable choice of species, rendering some plantations very susceptible to grazing
- * too little extension work by the forest personnel after the initial three years
- * rivalry between various political groups and neighbouring villages

The most important reasons were nevertheless grazing and browsing Large parts of the failed areas have, however, potential to develop as the root systems of some constantly browsed and thus suppressed planted species are still intact Natural regeneration of *Acacia auriculiformis* appeared in many cases However, these sites must be given adequate protection to facilitate survival and development

It was noticed that success in village woodlots was closely associated with the success of people's participation Wherever the village protection committees were active and developed their own approaches to protection and benefit sharing, the plantations had survived In addition to government sponsored committees, in Orissa a large number of indigenous committees have also sprung up, described later We first discuss the farm forestry programme and then the availability and distribution of fuelwood from government sponsored projects

Farm forestry in Orissa

Except in the Himalayan and regions of high fertility and steady rainfall, elsewhere trees did not form an important component of the farming systems in India Tree density on farms has declined over the years, the area under privately owned tree crops and groves falling from 2 77 per cent in 1951-52 to 1 15 per cent by 1980-81 When farm forestry was introduced in the late seventies with a view to fulfilling subsistence needs of rural households for fuel, farmers in the agriculturally surplus and commercial regions of the country saw in the programme an opportunity for substantial cash income as well as considerable savings in terms of labour and supervision inputs This led to the eucalyptus boom in the early eighties In subsistence regions, such as Orissa, only a few trees were grown primarily to produce goods for use within the family and in various agro-forestry combinations in which the trees complemented or supplemented other crops, rather than replaced them Most farm-level tree cultivation was of a kind which was low-risk, requiring only marginal adjustments to existing farming practices But the picture was radically different in the agriculturally surplus states, where an increased farm income was the driving force, as the farmers felt that by growing trees they could get a better return on their land, labour and other inputs

Constraints in Orissa - The agrarian structure of the eastern and tribal India is characterised by heavy dependence on grain production, smaller holdings, low overall incomes, a less marketed surplus, imperfect credit markets, more dependence on the village merchant for marketing the small surplus, inter-locked credit and output markets, less monetisation, less diversity of rural incomes, greater debt bondage, a less developed infrastructure for the supply of agriculture inputs, greater insecurity of land tenure, and on the whole poor human capital as far as enterprise is concerned These conditions can at best promote low intensity tree growing strategies for home consumption, and are not conducive to market oriented high intensity tree planting. Subsistence regions do not accept cash crops easily, and when these are introduced indiscriminately, poor farmers may be harmed rather than helped Cases of distress sales by the poor peasants to contractors at a throw away price a few years before the crop matures are often reported

Tree growing has been constrained in the monocropped India by other factors too First, young trees require protection from cattle, especially in the fallow season, when the village livestock is let loose to browse agricultural residues and stubbles During these months in a monocropped village cattle is generally not accompanied by a herder On the other hand, in irrigated villages a tradition is slowly emerging of herding cattle during the cropping seasons Despite ecological necessity and the easy availability of marginal and degraded lands, protection of young seedlings is difficult in monocropped villages compared with irrigated villages

Second, most of India's forests are located in areas of backward agriculture Villages in this region of low productivity often have vast, though degraded, open access lands Unlike annual crops which are grown on private lands, trees also occur on forest and other public lands Open access to public lands may vastly reduce the cost of obtaining tree goods for a gatherer, which may work to the disadvantage of a grower Thus, the concept of trees as a free good to be obtained from public lands inhibits investment of personal labour, land and capital in tree planting Proximity to forest lands affects private tree growing in other ways too State often restricts farmers' right to freely harvest the trees on private land in the interest of either conservation or of checking theft from forest lands These create rigidities in the free flow of products This may make planning of likely incomes from trees extremely difficult for a farmer Lastly, if similar products are raised on forest lands, which are marketed through the state machinery, farmers may find it difficult to compete with the state and get a remunerative price, particularly because the traders may be less interested in buying from dispersed producers, and may prefer to deal with the centralised bureaucracy Evaluation of the first phase of the Orissa Social Forestry Project noted that raising of eucalyptus on forest lands was one of the reasons why farmers did not feel attracted to grow commercial trees on their plots

Suggestions for subsistence regions - The above factors have limited the spread of market oriented farm forestry to the subsistence regions A different approach is required, which would be in harmony with the ecological characteristics of these regions First, a great deal of research needs to be done to identify species which complement agricultural production, as farmers' primary landuse continues to be crop production Thus the objective should change from "how can farmers be persuaded to grow trees" to "in what manner technology can help in increasing overall production from marginal lands by meeting farmers' priorities?" Ultimately the programme must improve the productivity of degraded private lands, if it is to be sustained over a long period There are some known indigenous practices, which use trees to improve land productivity Similar practices have to be introduced extensively in these regions For instance, one should give greater importance to species like *Siddha* in Orissa which can easily provide a great deal of fuelwood to the poor families, as it can be continuously harvested for fuelwood It also does not require any decision about distribution between the rich and the poor Such a tree is not of much interest to the rich, as it requires labour for gathering Thus by default the benefits are available for the poor primarily If such species require more time at the nursery stage these could be raised in the central nursery, and then transported to the temporary nurseries

It is difficult to rehabilitate degraded lands without introducing moisture conservation and water harvesting measures Such measures are needed for all rainfed areas put to biomass production The soil conservation technology in India has so far focussed primarily on structural works for controlling and disposing of run-off rather than capturing the maximum amount of moisture in the soil and retaining it for as long as possible to support crop growth It is better to adopt in-situ moisture conservation practices through planting of suitable grasses and trees which may also provide sufficient protection against erosion

Equally important are institutional constraints in watershed management programmes Studies of similar other programmes show that planning, organisation and management have been issues of major concern in all projects In particular, the impact of watershed treatments has been impaired by poor coordination between line agencies, and there has been a marked absence of land user participation in treatment planning and implementation

Unfortunately, watershed approach and agroforestry research for different agro-ecological regions has remained a neglected discipline so far Due to a tradition of competition for land between the Agriculture and Forest Departments of the government, both have viewed agroforestry with suspicion The Forest Department has even gone to the extent of banning agroforestry on forest lands by law!

Problems of allottees - Under the Forest Farming for Rural Poor (FFRP) scheme, landless farmers are allotted 0 5 hectare revenue land (wasteland), and are given seedlings to plant the same If the farmer shows satisfactory progress (survival of trees) after three years, he is to be issued a usufructuary lease-'tree patta' Even though the scheme has been in effect since 1985, no pattas have been issued as yet The question of how to do it was referred to the central government, but it concluded it to be wholly within the jurisdiction of the state government to issue the pattas Since this decision, the matter has been with the Government of Orissa The question of delays in issuing of usufructuary rights - pattas - to the beneficiaries of the Farm Forestry for Rural Poor component is a source of apprehension for most of the farmers involved

Because of the delays in issuing of pattas allottees feel their legal status is very precarious They believe they have no legal right to the planted trees until the written patta is issued, with the effect that no farmer has applied for Timber Transit permits as yet Several farmers interviewed claimed to have had trees stolen from their plantations without being able to file any complaint with the police They do not know how to convince the police that they - landless as they are - do own trees

Commercial regions - Some regions in Orissa, such as the coastal areas, are more suitable than others for market oriented farm forestry Here the approach should be to link them with markets and industry This would require a review of legal restrictions on harvesting and sale of trees

In the case of wood from plantations under farm forestry and FFRP, the Timber Transit Rules apply These were amended in 1991 and 1992 especially to facilitate trading in the wood produced under these components Now a transit permit is no longer needed for the two main species grown in the project, eucalyptus and *Acacia auriculiformis* But such restrictions continue for other species, such as bamboo and casuarina The procedure for obtaining transit permit is as follows

Before felling trees, ownership of the land and the trees must be certified by a 'joint verification' by the Revenue Department and the Forest Department This entails officials from both the Revenue and the Forest Department inspecting the produce in situ

After the joint verification, the farmer submits a list of conversions of trees and bamboos felled to the District Forest Officer (DFO) The DFO verifies (by physically marking the wood with the forest department hammer) that only what is mentioned in the list really is to be transported

Thus the whole procedure requires three visits to the site by Revenue and Forest Department officials and some communication between the farmer and the said departments Understandably, a farmer finds it cumbersome to approach two different departments on at least three occasions, especially since communications between a remote village and centralised departments are bound to take time

Due to the degree of complexity of the transit permit rules, not many farmers can be expected to fully comprehend them, a factor that might render the farmers easy targets for exploitation A survey of 12 villages in Sambalpur district in 1991 showed that only 60 per cent of the farmers interviewed had any conception of what the transit rules signify Of these, hardly 10 per cent had sufficient knowledge to explain the procedures of obtaining a permit

Lastly, government should stop subsidies on government supply of wood to industries, thereby forcing industry to buy from the farmers at a remunerative price The entire programme of farm forestry will be frustrated if captive plantations and subsidies continue FD could also initiate schemes for linking farmers with industries, in ways similar to the linking of poplar growing farmers with a Swedish match factory in north India Farmers will mostly produce eucalyptus for the paper industry, of which lops and tops can be used as fuelwood

Production for the market - Though market demand for forest products is likely to conflict with the goal of increasing supplies to subsistence users, it is essential to the success of farm forestry, and in particular of FFRP, which depends upon growers being able to sell at least part of their output Fuelwood markets and marketing in Orissa are quite complex A three-tiered price system exists - the heavily subsidised price applicable to rural people for their own use, the administered price paid and charged by the Orissa Forest Corporation, and the free market price The situation is complicated further by a multiple supply system headloaders, merchants, contractors and the Corporation

One effect of the subsidised prices is to create a very low cost source of supply of wood available for use as fuelwood; priced at well below the cost of replacement of growing stock through investment in plantations As long as this source is available, growers are unlikely to be able to sell their trees to middle men as fuelwood at a price that would be commensurate with the costs they have incurred.

The low value of fuelwood also means that in most situations it is likely to be a less profitable crop for farmers than the growing of trees for sale of poles, construction timber, fruit, etc This needs to be reflected in the choice of species and management systems recommended to farm forestry and FFRP beneficiaries It is likely that fuelwood production will be profitable only in a few special situations - for example, on the agriculturally marginal sandy soils of the coast close to markets, or when they can themselves sell directly to markets, so benefiting from the much higher prices for the new product as compared with the price for the tree.

The relatively low market value of fuelwood undoubtedly also helps explain the preference villagers have been expressing for tree species which primarily yield some other product - timber, fruit, bamboo raw material for further processing, etc These not only have a higher market value, but also are less easily substituted by other locally available raw materials A shortage of wood for construction or of bamboo for local artisans is thus more sharply felt, and it likely to have higher costs to the villager, than shortage of fuelwood

The multiple species woodlots, stocked to produce such locally sought after materials, are therefore consistent with the forest products supply-demand situation prevailing at the village level But it does mean that what is being created is a resource with a considerable market value This raises once again the question of how well this will serve the needs of the poor for subsistence supplies

A village level study indicates that farmers possess a very limited knowledge of prevailing market prices and of the produce in demand Only 45 per cent of the farmers had any idea of where to market their produce (only 7 per cent had a good idea though), while 55 per cent of all farmers had no idea of what price to expect Most of the price expectations tended to be above the prevailing market price The implication of this low level of knowledge is that markets will not be able to function efficiently since one of the basic pre-requisites of market efficiency - full, or at least sufficient, information among the actors, is not fulfilled In practice it will mean that farmers risk exploitation by buyers Lack of knowledge immediately places the farmer in an inferior position to a buyer who has knowledge of prices prevailing, and what type of produce is in demand

A further legal impediment to commercial activity under the project is the legislation relating to the sale of trees by members of the scheduled tribes and scheduled castes Such sale requires a special permit Although this legislation was introduced to protect those to whom it refers against exploitation (many tribals, for example, own trees having a timber value of which they might be unaware), it is of course two-edged Many of the project beneficiaries are subject to this legislation which needs to be reviewed

Fuelwood distribution from community woodlots

One of the main factors sustaining people's involvement in the SIDA project is their expectation of sharing its material benefits In areas where intermediate produce from woodlots had been distributed, the following methods of distribution were observed

- twigs and branches were made into bundles of equal size and distributed on the basis of one bundle for one kitchen
- where economically better off sections preferred not to take material, it was sold to whoever was willing to buy at nominal price and the proceeds were remitted to the village fund In such cases the buyers were invariably the poor
- fallen dry leaves were allowed to be collected by interested people on a "sweep and carry basis"
- where damage to standing trees was observed to be a consequence of too many people entering a plantation for sweeping, a contract to sweep was given to one or two persons only The contractors were permitted to sell the leaves at 0.25 Rs per 5 kg to the villagers who protected the plantation and at twice that price to members of other villages

Each of these methods of sharing the forest produce has its merits, although one may have reservations regarding the last, which relies on contractors and requires that the poor, whose need for fuel is the more acute, have to pay a price, however, small But the merits and demerits of the sharing system are less important than the fact that the villages are developing their own innovative ways of sharing forest produce equally

Subsistence use of fuelwood within the village is also bound to be increasingly affected by the growing market for this product, and the monetary value this places on it In practice, the village is not isolated from the market economy, so that villagers both communally and individually could find it more advantageous to sell their fuelwood production outside the village than to use it themselves Some villages already see their tree resource as being more valuable as a source of revenue to finance communal projects and activities than as a source of materials for use within the village This is hardly surprising, given the lack of alternative sources of communal income

Economic pressures are therefore likely to encourage the diversion of village forest output away from local subsistence use to higher valued market outlets The provisions in the village forest rules designed to prevent sales outside the village may be neither enforceable nor in the interests of the village as a whole

This assessment, if correct, clearly has very fundamental implications for some of the main objectives of the government projects, the question of how to provide for the fuel needs of the poor probably needs to be rethought Though programmes to introduce improved stoves, gobar gas and other sources of energy may make useful contributions for those who can afford them, most of those who presently depend on gathered supplies of biomass fuels will continue to have to do so More attention might usefully be directed to increasing resources of fast growing high yielding woody shrubs These can often be diffused at much less cost than trees, they can be cropped more frequently to give a more even flow of fuelwood, and as they do not have alternative uses the material they produce is less likely to be diverted to market outlets

Independent initiatives of villagers

As already mentioned, in addition to government sponsored committees, in Orissa a large number of indigenous committees have also sprung up Community based forest protection is now new to Orissa Communities claim to have taken up protection as early as 1950s Guesstimates of the area under protection and the number of communities involved range from 1,87,000 acres and 1,181 organisations to 1 5 million hectares and 6085 villages committees (Forest Department records) There is, however, no consensus on these figures

Reasons for forest protection by Committees - Orissa's acute poverty provides a challenge, and can also be seen as a positive factor, as it forces almost the entire population in a village to be dependent on forest resources, and this dependence helps in the evolution of a viable village institution The Orissa upland settlements are more homogeneous in caste, with one tribe usually dominating both in land and number A study comparing success of collective action in the poor state of Orissa with Gujarat, a richer state, noted that in Orissa, livelihood options are almost nil, whereas in Gujarat migration or agriculture has provided an option to the communites to cope with the problem of deforestation Hence in Gujarat despite external intervention either by the Forest Department or by NGOs to act as catalysts the programme has only been moderately successful In Orissa, most FPCs have come up on their own initiative and have survived with almost no incentive from government Finally, remoteness from roads and markets further helps in retaining mutual obligations, and discourages poaching by outsiders In remote villages, fear of reprisals from village elders deters too frequent abuse of common resources

Another reason behind people's success is the lack of full control of the Forest Department over protected forests, which facilitates people's control over such lands In Orissa, unlike other states of India, the ambiguous status of protected forests provides a highly favourable environment for evolution of community management system The ownership of the protected forest lies with the Revenue Department and management effectively with none Only in case of a few demarcated protected forests, Working Schemes have been prepared by the Forest Department Thus large areas of protected forests have been left unmanaged As the forest started receding further from the villages, the local communities realised that open-access usage of the resources was no longer a realistic proposition and some kind of user group regulation is required to safeguard the interests of the community This resulted in communities undertaking protection and management of forest, starting with protected forests Later at a few places reserved forests (RF) were also taken up for protection by communities which did not have adequate protected forests (PF) in their vicinity or under their control

Thus an important factor behind the success of community action has been the long term association of these villages with "their forests" and heavy dependence on these, and the loose control of the Forest Department over protected forests

In most of the cases protection efforts have started only when communities faced acute shortage of small timber for construction of houses and for making agricultural implements Although there had been considerable reduction in the availability of fuelwood over the years, this had hardly been an initiating factor Small timber requirement, monetary benefits, and greater availability of NTFPs such as sal seed has often initiated the process

When one or a few villages in a cluster take up the protection, accessibility to a particular patch by people from other adjoining villages are restricted This often triggers off the protection movement in the nearby villages whereby each village start asserting its right over a patch of land This restricts each other's access

Leadership plays an important role in the introduction of the concept of protection to a community In some cases it was provided from outside the village (by forest department personnel) whereas in some, it was provided by influential people from within the village Leadership was dependent on the population composition The more homogeneous composition the better was the leadership

Rights of villagers over the protected patch play a critical role in the initiation of protection effort Where people have been assured that benefits would flow to the community, protection could be brought about However, most of the villages in a cluster took up protection only after they had seen the rights of other villagers over the protected patch being recognised by the forest department, although informally This reflects the importance of clarity in the rights of the villagers over the protected patch

Institutional arrangement evolved

Several kinds of organisations have been formed at the village level to take up the management of forest, Youth Club (YC), Village Council (VC), and Village Forest Protection Committee (VFPC) VFPC are generally of two types, one that is formally formed by Forest Department under the guidelines issued for the purpose and the second type being a sub-committee of the VC entrusted with management aspect of the forest In some villages although a formal VFPC had been formed by the forest department, management was being looked after the YC Very few people were aware of the composition of the formal committee or the area that they were protecting

Budhikhamari, where more than 55 villages were jointly carrying out protection and which has received several awards, was unique in this aspect The VC of the individual villages were looking after protection and each village council was represented by a president and secretary in the central committee called the Joint Protection Party (JPP) Each organisation irrespective of its kind had a president and a secretary generally elected by consensus. Care was taken to involve people from all sections in case the village had a heterogeneous population. Each community had a general body with one person from each household and a core group comprising 4-5 persons responsible for taking decision on day to day activities Most of the committees were found to be struggling under financial constraints In order to meet expenses incurred in the protection, collection was made in cash or in kind. Expenses were also incurred in conducting rallies for bringing environmental awareness conducting meeting, payment to watchman etc Revenue for this were chiefly from cleaning and thinning materials which was being sold to the villagers at a subsidised rate Other sources of revenue included, fines collected for the violation of rules by the people within or outside the village However, it was found to be insufficient to meet the expenses incurred in protection Funds collected by the VC from other sources such as from the village pond had to be diverted to the forest management This often proved to be a disincentive to the villagers particularly the weaker sections who perceive protection as an additional economic burden It was reported that the YC were highly effective in the protection aspect because of their tough stand against offenders and this had often been the reason why VC had handed over the protection responsibility to YC.

Fuelwood pressure shift

Fuelwood pressure shift in each cluster was very much evident Each village in a cluster had its own method of meeting its domestic energy needs The first source of fuelwood was within the village boundaries. Some hamlet/village had demarcated certain areas which included a part of Village forest and pasture land for the collection purpose In some villages, while protection was being done in one patch indiscriminate fuelwood collection was being carried out from another part of Village forest and pasture land While vegetation flourished in one part, degradation continued in adjacent patches Often the village forest was seen as the property of the village whereas the RF that of the department So, while protection of degraded Village forest was taken up, the well stocked R F was left as open access As a result, this forest is now reduced to an open scrub vegetation

This raises question as what would happen with respect to fuelwood availability if the total area around a village is protected? In such cases, the fuelwood pressure shifts to two other places First, to those distant reserved forests with good growing stocks which are managed without community protection Cycle-loads of fuelwood are illegally extracted everyday from such reserve forests by people of those villages with no area under its protection or if present was very small and highly degraded Conflict often emerged between cycle-loader and the people of the village through which they generally passed Cycle-load trading became a lucrative business as demand for fuelwood increased and supply curtailed due to protection efforts in the cluster

The second type of pressure shift has been to those PF and RF where the village committees were found to be less effective in their protection activities Lack of effectiveness was due to internal conflicts, financial constraints and lack of leadership

The problem of fuelwood pressure shift was relatively less in the Budhikhamari where more than 55 villages were jointly carrying out protection under an umbrella organisation of JPP Energy requirements were met partly from dried, fallen twigs from respective collection and collection of dried leaves has become a part of daily activity of tribal women in various clusters

A few trends need to be analysed here Why does a community protect a patch totally degraded with a view to get a significant benefit after two or three decades and not protect a well-stocked patch which would provide them benefits within a short span of time? It was generally felt by the villagers that it would be easier for them to assert their effort and not in the case of an already existing dense forest. Would this lead to a cyclic process of degraded forest developing into a well-stocked forest getting converted to a degraded one? Further, well-stocked R F or P.F. are generally not taken up for protection because of fear of threats from within and outside the village boundaries Threats emerge from those benefiting from a patch in terms of fuelwood and small timber when they are denied accessibility Thus degraded forests are brought under protection while well-stocked ones are left as open access property

The issue of fuelwood pressure shift puts serious doubts on the effectiveness of this kind of protection Can this pressure be contained in any way? Can the cluster approach, where all the villagers are involved in the protection provide an answer to this kind of problem?

Although the cluster approach of protection does overcome the problem of pressure shift certain issues in this regard need to be examined First is the kind of leadership required to organise such a large number of villagers under a common umbrella If inter-village conflict exists, then bringing all of them together may result in an abortive attempt to organise protection movement at a macro level Second, when a number of villages join together they often perceive their mass as their strength and sometimes they mis-utilise their power So before organising such a cluster what control measures should the forest department have to check such misutilisation of power? And what should be the ideal size of the joint committee for effective administration?

Equity issues

Looking at the equity aspects of forest protection from the broader perspective, there are large-scale processes causing inequalities between villages Some villages have to share a large forest area with many other villages, some have much smaller areas which they have to themselves or a few other villages, and some are not adjacent to forest areas at all Different rates of forest degradation and different degrees of awareness and concern have prompted some villages to take action and to exercise protective control over some forests much earlier than other villages

Some smaller villages are concerned about being disadvantaged by the larger villages with whom they share access to a forest area. Members of a tribal village adjacent to Damasahi expressed criticism of people from Dhamasahi village because they had taken over land that had been planted with trees given to the village by the government When asked what sort of problems they expected in the future they said that as the forest gets thicker more people will be attracted and there will be fighting, emphasising that they are "a very small village" and would find it difficult to oppose outsiders

Potentially, forest protection can lead to a win - win situation, in that NTFPs can provide significant benefits to the poorest villagers; but the conditions for such benefits to accrue consistently will not exist until there is a general acceptance of rule systems which allow for access to these benefits by the poorest

It may be that because in many villages it is the "richer" households that are least dependent on the forest Because of their relative status and authority, even NGOs who initiate community protection have pragmatically sought their active involvement in forest protection To have such people on their committee was useful for dealing with other villages and external authorities

Many village forest protection initiatives arise spontaneously when the forests have become very seriously degraded, to the point where even the poorest are having great difficulty getting any of their needs met from forest resources, for example, when rootstock are being dug up for firewood At these times it is likely that everyone in the village, even the poorest themselves, see forest protection as a win-win situation, where everyone can gain, and few if any will lose

Nevertheless, there are circumstances where the needs of the poor will be at risk Firstly, in forest areas where poorer households already have a stake in a forest which is still giving them some return, and in forest areas, especially plantations, where the distribution of returns from future cropping are yet to be agreed upon

One problem area in particular are those households which are wholly or partially dependent on the collection and sale of firewood for income. Such people cannot stop cutting wood in forest areas even after the introduction of forest protection in their area Sometimes wood-cutting has been displaced to more distant "unprotected" forests Often wood-cutting has persisted in the same village, albeit under continuing pressure to stop from the other members protecting the concerned forest In both cases wood-cutting families are paying the costs of protection, in increased walking distances, or in harassment and fines The basic issue is of the alternatives livelihoods available to those dependent on the forest, and that does not seem to have been addressed as a development issue by the FD

In one village, the idea of establishing a firewood plantation to meet the needs of wood cutters was rejected on the grounds that the best firewood trees concerned cannot be grown in plantation It also seemed that the allocation of any special usage rights to forest areas to particular groups would inherently be a problem, because it would open up the possibility of other groups making special private claims on common land In another village, a group of 35 to 40 potters who use wood to fire their pots are directly dependent on the forest It would be ideal if an area of land should be left for the use of potters, but this advice was rejected by the community, in favour of a policy of total protection According to potters in the village, they need about three quintals of wood every month to fire 300 pots Now they are having to purchase wood from the Corporation depot, and collect brushwood from a forest 10 kms away, and at the same time they are not obtaining sufficient wood to maintain their past production levels In this village forest protection is not a win-win situation

The equity issues concerned with current management of the forests pale into insignificance when compared to the impending problems of the future The forests and plantations are maturing assets, increasing in value and visibility every day None of the villages contacted had established any long-term management plans, especially for the allocation of benefits from plantations It could be argued that this is in fact an unreasonable expectation at present, where sustaining what exists is the main task at hand However, some current decisions, such as the planting of trees over a whole area, versus part-by-part, year-by-year, have implications for the ability of the villages concerned to take continuing yield from the land in the future This is in turn will affect the management of claims for benefits, with one-off distributions being more problematic

Arrangements for guarding protected forests vary between villages, some use voluntary labour on a rotating basis, others collectively pay for a watchman It could be argued that the volunteer-based system is more equitable, because for the poorest households cash is in greater scarcity than labour time The optimal arrangement would seem to be the situation found in some villages, where volunteer labour is used by most (called the thengapally system) but the richer households in practice paid poorer people to do their shifts

Gender issues

When women were asked about their preferences for different tree species for plantation, a marked difference was found between the better-off castes and the poorer Harijan (low caste) women The better-off caste women expressed their preference for teak and Sal trees which can be used for furniture, whereas the poor Harijan women expressed their preference for fruit-bearing trees like Mango, Jackfruit, Guava, Ber, etc

Despite the above differences, in general all groups of women appear to have understood the need for forest protection and have expressed a positive attitude towards forest protection activities In a village women (not low caste but not rich) said that the most important benefit next to fuelwood was the availability of privacy for defecation. They said that when the hills and the foot hills were barren they used to have to walk very far away from the village to find privacy It was very hard especially if they had to go during midday in summer But now the regeneration of bushes has made their lives easier

In contrast to the better-off women, the poorer low caste women always emphasised their need for fuelwood, which they think can be met from the protected forest This was for their own consumption and in some cases for selling The better-off women who have purchasing power to buy fuelwood did not see the need to protect forests in order to meet their fuelwood requirements

In the overall analysis of the problem of environmental degradation, the protecting committees feel that both men and women are affected equally and the benefits of forest regeneration are shared equally by men and women One section is not affected in different ways from the other On the basis of this understanding, the Committees have never felt the need to consult women specifically in the planning and implementation of the project activities In none of the successful Vcs or Ycs women were represented or consulted These were exclusive male societies

Problems with government

Rather than trying to locate barriers to community action in structural and sociological factors, or in inter-and intra-village problems, greater attention needs to be paid to governmental policy, which has often hampered such initiatives Joint Forest Management (JFM) has been promoted in most states by the Forest Department. However, in Orissa there are indigenous committees protecting forests since a long time and the establishment of these committees had nothing to do with the efforts of the Forest Department, although individual forest rangers have often been involved in giving guidance to such committees Thus today there exists no Joint Forest Management in Orissa However, there is forest protection and management by village committees (VFCs) - with the Forest Department as a passive bystander/ supporter or not knowing about it at all The initiatives taken by the state government have often resulted in confusion, as described below

No consultation - The State Government orders of 1988, 1990 and 1993 in Orissa have officially led to formation of nearly 23,000 VFCs Some of these VFCs are functioning very well, but a large majority have problems, or many may exist only on paper. Often, they were brought into being in a hurry without giving attention to details, such as adequate consultation with local villagers In some cases, the area being traditionally protected by village was allotted to some other village for protection In some other cases, villages considerably away from a forest patch were allotted area while the ones in the proximity were neglected. Such events occurred due to formation of VFCs on paper by field staff at Range Headquarters This is a good example of how well intentioned policy decisions are liable to lead to unforeseen and undesirable results, if not implemented properly

No authority under law - The resolutions do not have the strength of law Therefore, VFCs are extra - legal bodies The state government resolutions recommend village level committees as functional groups However, these committees have no legal and statutory basis, and it may be difficult for them to manage resources on a long term basis The VFCs have no power of their own to punish or challenge offenders Their authority over the forest is very often questioned This can be avoided if the VFC has legal powers over the patch it protects

Recognise informal committees - One of the first need of indigenous committees is official recognition in writing through a letter which the village people can keep It would be useful if the names of all families involved in protection is mentioned in the letter However, this is not provided for in the Rules On the other hand, Orissa government has a bad track record of not honouring commitments, or at least honouring them with great delay, as in giving pattas to FFRP beneficiaries, creating village forests, etc These committees can also be given some financial help, so that they could buy torches and dress for the watchman

Ideally speaking, at some stage the informal forest protection committees need to be formalised to give them legal endorsement The transition/transformation from informal to formal organisations should be made as smooth as possible, with efforts to retain the strengths, viz flexibility, representativeness, and acceptability by the community, of the informal organisations The composition of new committees should be such that it incorporates these strengths Necessary changes may be made in the existing Government Order for this. The process of formalisation of informal committees is very crucial and needs to be handled with utmost care

Reserve forests treated as open access lands - In reserved forests of Orissa a forest patch does not have a well-defined and recognised user-group, admitting the rights of the entire population of that region or the entire forest area This kind of a 'right-regime', which makes reserve forests open-access lands, is not conducive to successful protection, as rights of contiguous villages protecting forests may come in conflict with those of distant villages, not protecting but still having rights to enjoy usufruct Therefore, at least in JFM areas, use rights should be reviewed in order to put them in harmony with the *'care and share philosophy'* which is the basis of JFM This would require redefining the village boundaries so as to include the reserve forest lands where JFM is to be promoted Inclusion of reserve forests within the village boundary will strengthen the claim of the protecting village vis-a - vis others

Demarcation - Demarcation and allocation of forest area to the village communities for protection is a pre-requisite to the proper functioning of the VFCs This aspect has not received adequate attention in the 1993 guidelines The result is that in some cases it has not been done while in some others it has not been adequately conveyed to the villagers

Demarcation and allocation should normally take the following into account the prevailing rights and concessions in the forest area, i.e , who uses it for which purpose, is it informal and seasonal as for example for fuelwood, MFP collection, head loading, and grazing and so on and whether the forest area is already being protected by some village or a group of people Neglecting these points will lead to either conflicts or irresponsible behaviour This is one of the reasons for the oft repeated complaint against village communities that they protect their forest area at the expense of adjoining reserve forests The counter point is that if they do not have the right to manage the reserve forest and practice exclusion, how can they be expected to protect it?

Uncertainty about sharing of produce - In the villages which have started protecting forests after the formation of VFCs or where the informal forest protection has been formalised, there is a sense of uncertainty over sharing of forest produce, both from the intermediate and final harvests This uncertainty arises from the extra-legal character of the VFCs, mutual distrust between the FD and the villagers, lack of knowledge about the legal provision and the general casualness with which the VFCs have been formed

The present formula of giving a share out of net income should be replaced by a share of gross income, which is easily understandable by the people The village communities should have the freedom to decide whether this will be individually distributed or deposited in the village fund

Rights of the VFC- The rights and responsibilities of village communities and the Forest Department have been specified in such a manner that the VFCs have been given most responsibilities and the FD most authority VFCs' rights over the forest patch are not mentioned specifically, only certain concessions for fulfilling bonafide requirements are spelt out

The VFC should have powers of a Court so that it can arrest and impose fine upto Rs 1000 which, if not paid by the offender, should be recovered as arrears of land revenue The VFC should have powers to compound an offence without any upper limit

The Rules should lay down general principles for expenditure on approved items The VFC in consultation with the DFO should be authorised to decide the financial norms Subject to these, the VFCs be free to spend upto 50 per cent of their annual income without obtaining sanction from above For the rest, they should send proposals to the Forest Officer concerned.

The VFC should have full powers to distribute and sell fallen fuel and grass to the villagers As regards sale of standing trees, the number of such surplus annual forest produce should be determined once in a year by the open meeting of the General Body of the VFC FD may send its representative to such meetings and advise the VFC on technical matters The VFC should be free to conduct auction of fallen trees in the presence of the entire village upto a value of Rs 10,000/- in a year Outside contractors or their agents should be banned to tap NTFPs Short training courses can be organised to equip the local VSS with the necessary processing technique It should be the duty of the FD to prepare a Working Plan and get it approved by the VFC If the FD does not prepare an approved Working Plan, the VFC will be free to prepare its own plan in the interest of conservation and development of forest

Innovative silviculture - In keeping with the new Policy species choice and silvicultural practices will need a change in favour of ususfruct based trees and multiple outputs. Where a large number of people have claims to forest produce, low management and low value output (but high in biomass) solutions have perhaps a better chance of success However, business seems to be as usual in the field, and commercial trees are continued to be encouraged and planted on forest lands For instance, FD's present management of sal seems to be for timber, and hence only one shoot is allowed to grow Since sal is an excellent coppicer we suggest that degraded forests and hills close to a village should be managed to maximise biomass, with many shoots, which can be pruned occasionally to produce fuelwood, besides giving sal leaves

Many of the forest ecosystems of India possess a high proportion of coppicing species, while water and soil conditions also permit rapid regeneration and increases in biomass Recent studies are also beginning to indicate that regeneration is linked to increasing biodiversity Natural regeneration through voluntary community protection costs between five to 10 percent of the amount needed to establish monocultural plantations on the same land area Studies in West Bengal and Karnataka indicate regenerating natural forests after 5 to 14 years of protection yielded growth rates between 3 4 to 8 8 metric tons of woody biomass annually, compared with 1 5 to 3 metric tons for plantations At the same time, the costs for plantation established averaged Rs 10,000 per hectare compared to a maximum of Rs 600 for natural regeneration

NTFPs flowing from naturally regenerating forests usually yield more income and employment to community members, especially women, when contrasted with monoculture plantations. Under natural regeneration many of the forest ecosystems studied also began yielding NTFPs much faster than degraded lands placed under monoculture tree plantations Many grasses and leaves are available after three to six months of protection Regenerating natural forests are also being associated with improved hydrological functions by slowing run-off, improving soil moisture and groundwater levels

Need for cautious approach

One problem with over-promotion of JFM is that it can lead to massive donor interest and funding support, which may exceed the capacity of the forestry bureaucracy to absorb. JFM may indeed have been promoted beyond the capacity to implement it JFM is process oriented and does not lend itself to becoming a target oriented programme Apart from the lack of institutional capacity, the technical skills to develop different silvicultural systems (to fulfil the varied objectives of management) also are insufficient For instance, research on economic and ecological impact of protection shows that although people's main concern is with fodder, protection beyond six years tends to close the tree canopy and reduce grass production Perhaps a much wider spacing is called for to maintain grass production which is one of the major incentives for community protection and management Similarly, most silvicultural research in India so far has been done on commercial species, and techniques for large scale regeneration of multi-purpose species such as mahua and neem are still to be developed

A development concept faces very different constraints and opportunities when it is new, unproven, and unaccepted, compared with when it is long-established and widely accepted - and the role of those who are in charge of its promotion must vary accordingly For example, much of the effort of the `sympathisers' of the JFM to date has concentrated on promoting the principles of JFM to the government, NGOs, and local communities Such promotion may be valuable in the early phases of a programme, but there are potential problems in sustaining it for too long The nature of promotion results in too much emphasis on positive aspects of the programme and too little critical analysis. At the outset it is important to be able to persuade key actors of the merits of JFM, but it eventually becomes important to temper this with critical appraisal, long-term strategies, and the building of capacity to implement such policies Care will need to be taken to ensure that JFM does not just become the next development bandwagon

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[1] Fuelwood is used here as a collective term for firewood and charcoal, but as charcoal only represents about 3 per cent of total wood, in round wood equivalent, the term may be generally taken as referring to firewood

[2] A lower estimate has been suggested by the National Sample Survey According to it, per capita consumption in the rural area in Orissa was only 340 kg of fuelwood

Biomass feed processing for energy conversion

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BIOMASS FEED PROCESSING FOR ENERGY CONVERSION

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1.0 INTRODUCTION

Biomass is a natural product of solar energy and therefore a renewable source of carbon and hydrogen which are the basic constituents of energy and chemical products Worldwide, the energy stored in biomass through photosynthesis is approximately 3x1021 J (90% in trees), each and every year, which is nearly 10 times the world's annual energy use [1] Even though the total renewable biomass resource for energy far exceeds the world's total energy requirement, its volume exploitation remains limited because of the present low cost of fossil fuels, the heterogeneous nature of biomass and the area over which the biomass must be collected for large scale applications

Biomass should be termed not only as a potential renewable source of energy but also as a renewable feedstock for chemicals. Technologically, biomass can provide all forms of energy and products normally derived from fossil fuels However, presently these cannot compete with fossil fuels in scale and capacity Meanwhile, biomass can be an attractive source of solid fuel either for its direct use or through conversion routes to meet the growing energy demands and to replace and conserve fossil fuels For most of the developing countries, devoid of oil resources, biomass use is a necessity Furthermore, there are worldwide wood shortages and people in rural areas are resorting more and more to agro-residues and cowdung Also, these resources are highly under utilised in developing countries by being put to inefficient combustion and causing widespread environmental pollution with its associated health hazards

Compared to coal and oil, the carbon and hydrogen constituents in biomass are highly oxygenated which are responsible for their lower heating values Their varying moisture and ash contents and comparatively lower bulk densities also put additional constraints to their utilisation for energy Bulk densities of some typical materials are given in Table-1

The biomass feed, especially agro-residues, are available in different shapes and sizes, such as husks, straw and stalks of various and numerous crops Because of this heterogeneous nature, the utility of these materials for energy becomes limited and energy conversion processes tend to become biomass specific In order to enhance the effective utilisation of these materials, it becomes imperative to prepare these materials These processes comprise of drying, commutation, compaction or briquetting and carbonisation to produce clean fuels. These feed preparation techniques add to conveneince, both for collection, transportation and storage of these materials and their efficient utilisation for energy

Before the biomass feed preparation techniques are discussed, it is important to know their basic characteristics and hoe these compare with other conventional fuels Biomass feed normally encompass wood, agro and forestry residues and municipal solid wastes (MSW) While wood is well understood and MSW, being a product highly dependent on the standard and mode of urban living, is rather complex and beyond the scope of this paper. Accordingly, the treatment is mainly directed towards the characteristics and processing of numerous species of agro and forestry residues

2.0 THERMOCHEMICAL CHARACTERISATION OF LOOSE BIOMASS

Biomass species, like coal are characterised in terms of their physico-chemical properties The physical properties are: shape, size and bulk density, while chemical properties are composition, heating value, ash constituents and their slagging properties In addition, other parameters necessary to understand their behavior during combustion are devolatisation characteristics. The comparison of some of the properties of biomass with those of conventional fuels is given in Table-1 & 2.

Table-1.0 Density (Specific Mass) and (Net) Calorific Value (Heat of Combustion) of Fuels

	Density (kg/m^3)		Calorific value	
	True	Apparent	(MJ/kg)	Kcal/Kg
LPG	560	-	45.3	10,820
Gasoline (petrol)	720	-	44 0	10,510
Kerosene	806	-	43 1	10,270
Diesel oil	850	-	42 7	10,200
Fuel oil	961	-	40 1	9,580
Coal	1250-1450	-	16 7-33 2	4000-8000
Coke (By product)	1750-2000	750-1100	29 7	7,105
Wood	500-1100	-	16-20	4500-5338
Wood Charcoal	1400-1700	300-600	29 8	7,130
Rice husk (11 4% wet)	1021	101	13 4	3,200
Natural gas	-		103m^3 at 1013mbar,0°C = 39 36x10^{9}J	

NB These values are approximate since the fuels vary in composition and this affects both the density and calorific value

Table-2.0 Typical Compositions of Solid Fuels

Fuels	Proximate analysis, %				Ultimate analysis,%					Heating Value Kcal/Kg
	Moistture	Volatile matter	Fixed carbon	Ash	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur	Dry basis
Wood										
Oak,dry	-	85 6	13 0	1 4	50 2	6 0	43 3	0 1		4,622
Pine,dry	-	87 0	12 8	0 7	52 6	7 0	40 2	0 2		5,338
Peat	56 8	26 0	11 2	6 0	23 1	9 6	59 6	1 3	0 4	4,625
Lignite	34 8	28 2	30 8	6 2	42 4	6 7	43 3	0 7	0 7	6,110
Coal	3-20	16-40	40-80	3-40	60-50	3-6	3-6	1-1 5	0 3-4 3	4000-8000
Bagasse,		80 5	17 0	2 5	48 0	6 0	43 2	0 3	0 1	4,430
Coke	0 8	1 4	87 1	10 7	85 0	0 8	1 2	1 3	1 0	7,105
Charcoal	12 0	1 9	83 1	3 0	84 0	2 3	10 7			7,130

2.1 Physical Properties

Physical properties, such as shape, size and porosity, indicated by true and apparent density directly influence the pathways of combustion for biomass For loose biomass species, bulk densities which are a function of their particle size distribution and tendency to stay loose or packed in piles, play equally important role in combustion These properties determine the surface area per unit volume exposed to flames during combustion, rates of particle heat up and volatiles released; flame stability, extent of particulate emission and overall thermodynamic efficiency Data on bulk densities of some typical loose and compacted materials are given in Table 3

Table-3 Bulk Densities of Typical Original and Processed Biomass Materials

Fuel	Grading (Kg/m3)	Bulk Density
Alfalfa seed straw	cube 30x30x50 mm, 7% moisture	298
Barley	cube 30x30x50 mm, 7% moisture	300

Bean straw	cube 30x30x50 mm, 7% moisture	440
Brown coal	air dry lumpsh	650-780
Charcoal (10% moisture)	beech	210-230
	birch	180-200
	softwood blocks	150-170
	softwood slabs	130-150
	mixed 60% hard/40% soft	170-190
Corn cobs	11% moisture	304
Corn stalks	cube 30x30x50 mm	391
Cotton gin trash	23% moisture	343
Chips	10% moisture	167
Coal	anthracite	830-900
	bituminous	770-930
Coke	hard	380-530
	soft	360-470
Olive pits	10% moisture	567
Peat	dust	550-620
	briquettes 45x65x60 mm	180-400
Peach pits	11% moisture	474
Prune pits	8% moisture	514
Rice hulls	cube 30x30x50 mm	679
Saw dust	loose	177
Saw dust	briquettes 100 mm long	555
	75 mm diameter	350-400
Straw	loose	80
	bales	320
Sunflower straw	cube 30x30x50 mm	203
Wood	hardwood	330
	softwood	250
	mixed 50/50	290
Walnut shells	cracked	336
	8 mm pellets	599
Wood, blocks	17% moisture	256

2.2 Calorific Values

The normal procedure employed to measure calorific value, by bomb calorimeter, gives Higher Heating Value (HHV) But what is normally utilised in combustion/gasification systems is the Net Heating Value (NHV) The determination of hydrogen content in biomass is essential to arrive at the net heating value By deducting the latent heat of water vapour formed during combustion from HHV, the net calorific value can be calculated

2.3 Ash Content)

Of all the constituents of biomass, variation in ash is significant in loose biomass. It varies from 1.5% in corncobs to 20-23% in rice husk, compared to 0 5-3 percent in wood. Based on ash content, various biomass species can be classified into three categories. low ash (1-4%), medium ash (4-8%) and high ash (>8%) This classification, along with equally important factor of shape categorised as powdery, granular and straw/stalk type materials, has been compiled and presented in Table- 4 0 [2]

Table 4.0 Classification of Biomass based on physical shape and size and in terms of ash content

Shape/size	**A Powdery**		**B Coarse/Granular material**		**C Stalk like material**	
Ash Content	**Ash**		**Ash**		**Ash**	
		(%)		(%)		(%)
Low Ash	Euclyptus saw dust	0 4	Kikar Acacia	0 6	Grewia optiva (Bhimal)	0 32
	Saw dust (Saw mill)	1 3	Walnut she	0 7	Elephant grass (Miscathus)	0 4
			Labakshi	0 75	Khair wood	0.8
			Amla seeds	1 2	Corn cob	1 2
			Cedar cones	1 5	Jute stick	1 2
			Waste from Dabur	1 5	Vitec Negundo	1 5
			Pine needle	1 5	Carissa carandas	1 6
			Harid	1 6	Soyabean stalk	1 5
			Coffee spent	1 8	Sunflower stalk (without spongy part)	1 9
			Bagasse	1 8		
			Coconut she	1 9	Adhatoda vasica	2 0
			Khandasar bagasse	2 6	Mulberry stick	2 1
			Fibre of green coconut	2 8	Artemisia parviflora	2 3
			Subabul leaves	3 6	Tea bush stem	2 5
			Groundnut shell	3 6	Rhuscotins(Tunga)	3.0
			Tea waste	3 8	Besaram	3 1
					Jowar straw	3 1
					Arhar stalk	3 4
					Lantana camara	3 5
					Mallotus phillipemis	3 7
					Thakal kanda	3 8
Medium Ash			Cherry coffee	4 0	Congress Grass (Parthenium	4 2
			Tamarind [illegible]	4 2		

					Hystophorus)	
			Sweet sorghum bagasse	4 2	Sunflower branch	4 3
			Coffee chaff	4 6	Gokhru(Xanthium Strumrium)	4 5
			Cotton shells	4 6	A-Grade grass	5 2
			Tannin waste	4 8	Chirotha	5 2
			Waste from Dabur (Bark)	5 1	Castor stick	5 4
			Arcnut shell	5 1	Bidens	5 6
			Coconut coir	5 2	Dry potato waste	5 8
			Coffee husk	5 8	Ragi stick	7 1
			Coconut waste (top cover)	6 3	Sweet sorghum stalk	7 4
			Tea leaves	6 7		
			Soyabean husk	7 2		
			Sugarcane leaves	7 7		
			Bagasse pith	8 0		
High Ash	Industrial Bamboo dust	9 9	Cover of castor oil seeds	9 0	B-Grade Grass	8 8
	Tobacco saw dust	19 1	Sal seed husk	9 4	Jowar stalk	9 5
	Fly dust	19 2	Sunflower	10 1	Ageratum conizoides	9 5
	Jute dust	19 9	Water hyacinth	10 8	Centinious ciliares grass	9 7
	Deoiled bran	28 2	Mentha piperetha	13 5	Banmara weed	10 9
	Dal lake weed	48 7	Effluent sludge	14 4	Ficus	10 9
	Tobacco dust	49 4	Mustard shell	15 4	Hybrid Napier grass	11 5
			Senna leaves	17 25	Ground paddy straw	15 5
			Spirement	18 1		
			Salseed leaves	19 7		
			Decaffeinated Tea waste	19 8		
			Rice husk	22 4		

3.0 BIOMASS CONVERSION PROCESSES

The Biomass conversion processes can be classified as physical (briquetting etc), biological (biogas recovery), chemical (hydrolysis for chemicals like ethanol recovery) and thermochemical (combustion gasification, pyrolysis or liquefaction) In this paper, we are mainly concerned with the feed processing techniques of biomass for thermochemical processes As the name indicates, these processes are initiated with heat and take place at elevated temperature (300 to 1000°C) These processes are illustrated in Figure 1

4.0 INTEGRAETD BIOMASS TECHNOLOGIES FOR ENERGY AND MARKETABLE PRODUCTS

These technologies have been identified taking into consideration the level of development in infrastructure and markets for products and energy in developing

PRODUCTS OF PYROLYSIS AND THEIR USES

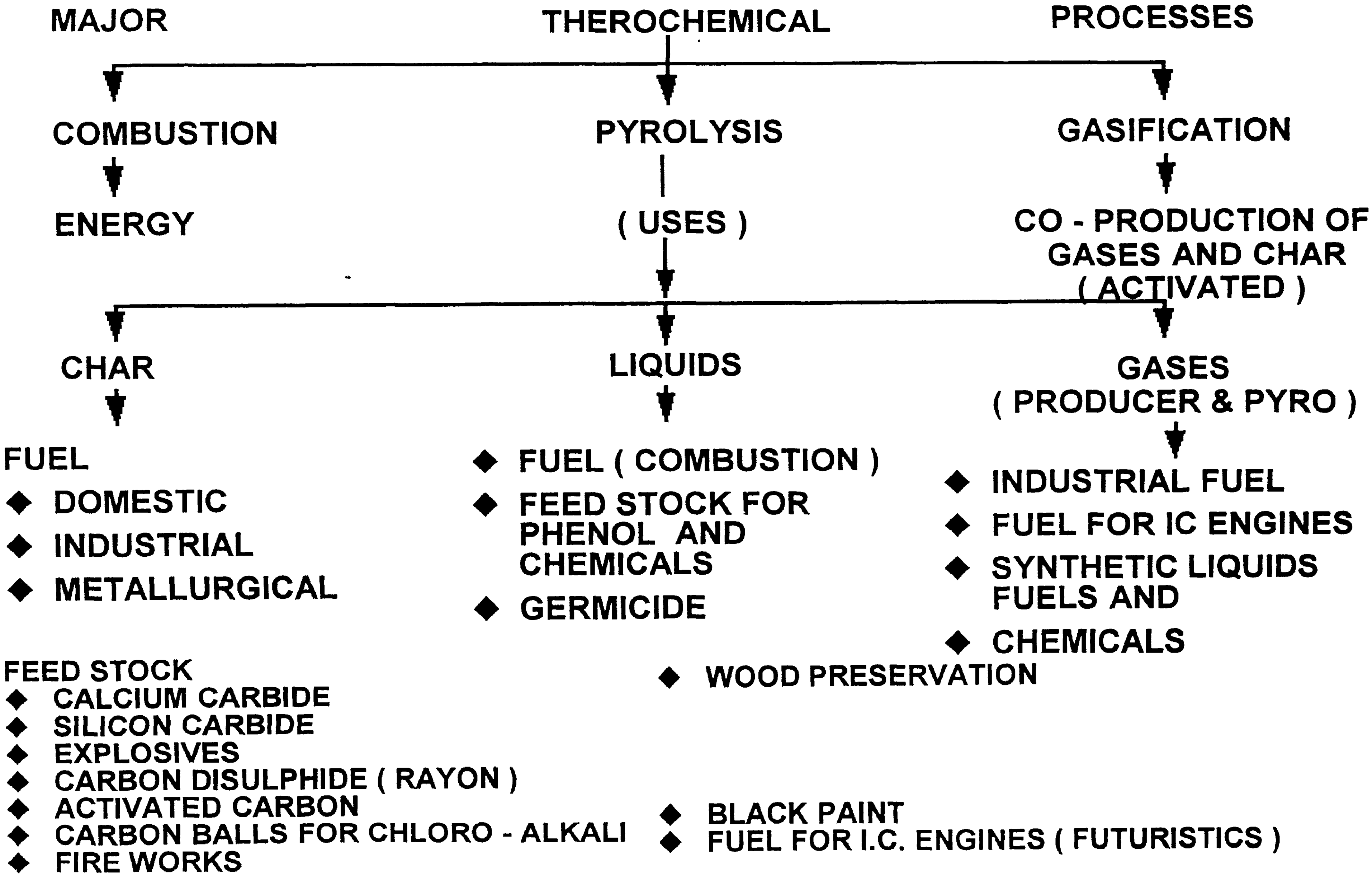


Fig 1.0

countries

Of all the biomass based thermochemical conversion processes, such as combustion, gasification, liquefaction and pyrolysis, the last one is most flexible with maximum potentials Through this route, we can obtain gases for power generation or for clean burning in boilers, liquid products as industrial raw materials and solids like char as metallurgical fuel and also as clean domestic fuel, replacing firewood and petroleum products. Further, depending on raw material used and demand for products, one can vary the proportions of these products The basic concept overriding the development of these technologies is that, instead of producing useless ash through combustion with its associated disposal problems, the ash should be recovered with varying amounts of carbon The resulting product can be used as such or briquetted and sold as industrial/domestic fuel Based on biomass characteristics of size, ash and moisture content of biomass, these technologies have been classified into four categories, each one identified to suit a set of biomass species having similar properties

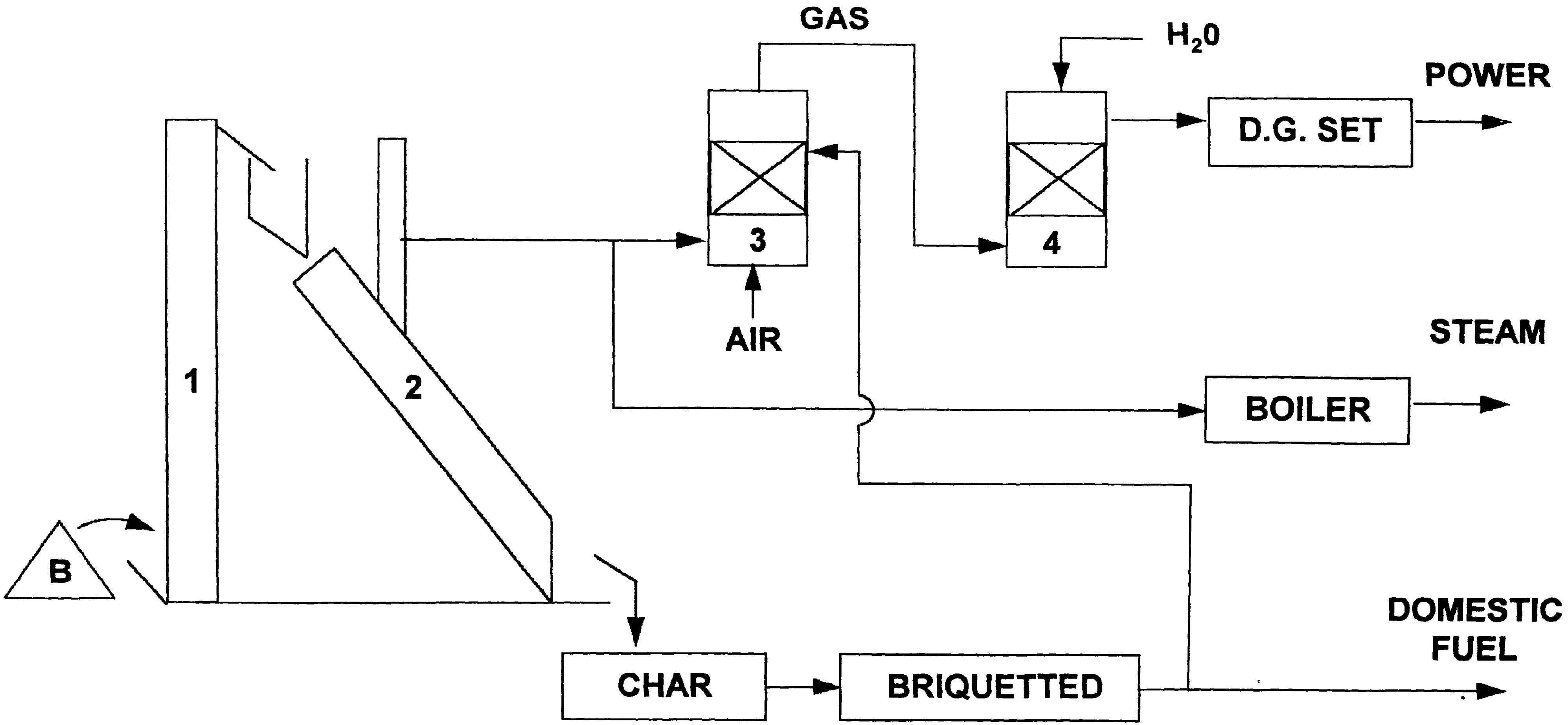
Category I, includes those agro-residues which have low ash (<4%) and are available in large sizes of 20 mm and above in diameter Some of the major species falling into this category are pigeon pea stalks, twigs, lantana, corncobs and similar types of woody biomass.

These materials can be gasified in moving bed gasifiers of down or updraft configurations. The hot gas produced can be clean combusted in boilers with an overall efficiency of 60 to 70% The other main advantage of the downdraft unit is that the gas can be used for power production. The gases are cleaned, cooled and then injected into I C engines About 70 to 80% of the diesel input to diesel engines can be saved About 1 3 kg/kWh of woody or 2 0 kg/kWh of non-woody biomass are consumed A simple version of these gasifiers which have been accepted for rural electrification involves the route of partial carbonisation of biomass and then using the char as the feed to the gasifier

Category IIA, includes agro residue species under category I and others with low ash but available in comparatively smaller size like saw dust, groundnut and walnut shells, jute waste, pine needles, mustard stalks and similar materials including industrial organic wastes These are recommended to be fed into gasification cum carbonisation systems which are suitable for simultaneous production of gases, liquid and solid products

Many types of reactor configuration can be used One of the promising and already commercialised systems is the inclined grate unit This system consists of an inclined grate gasifier cum carbonisation chamber made out of refractory in which part of the gases or char are combusted with controlled air to maintain the requisite temperature for conversion The quantities of char, gases and liquid can be varied The typical product distribution is 20% char, 25% liquid and 55% gases The char production can be increased even to 40% but then the amount of gases available is reduced

Char is sold as such or briquetted to any desired size by well established technologies These are used for ferro-alloys, calcium carbide, silicon carbide and carbon disulfide for



B - BIOMASS FEED
1 - ELEVATOR
2 - GASIFIER
3 - TAR CRACKER (BRIQUETTES)
4 - GAS COOLER & CLEANER

FIGURE - 2 HIGH ASH BIOMASS UTILISATION - CLEAN TECHNOLOGY

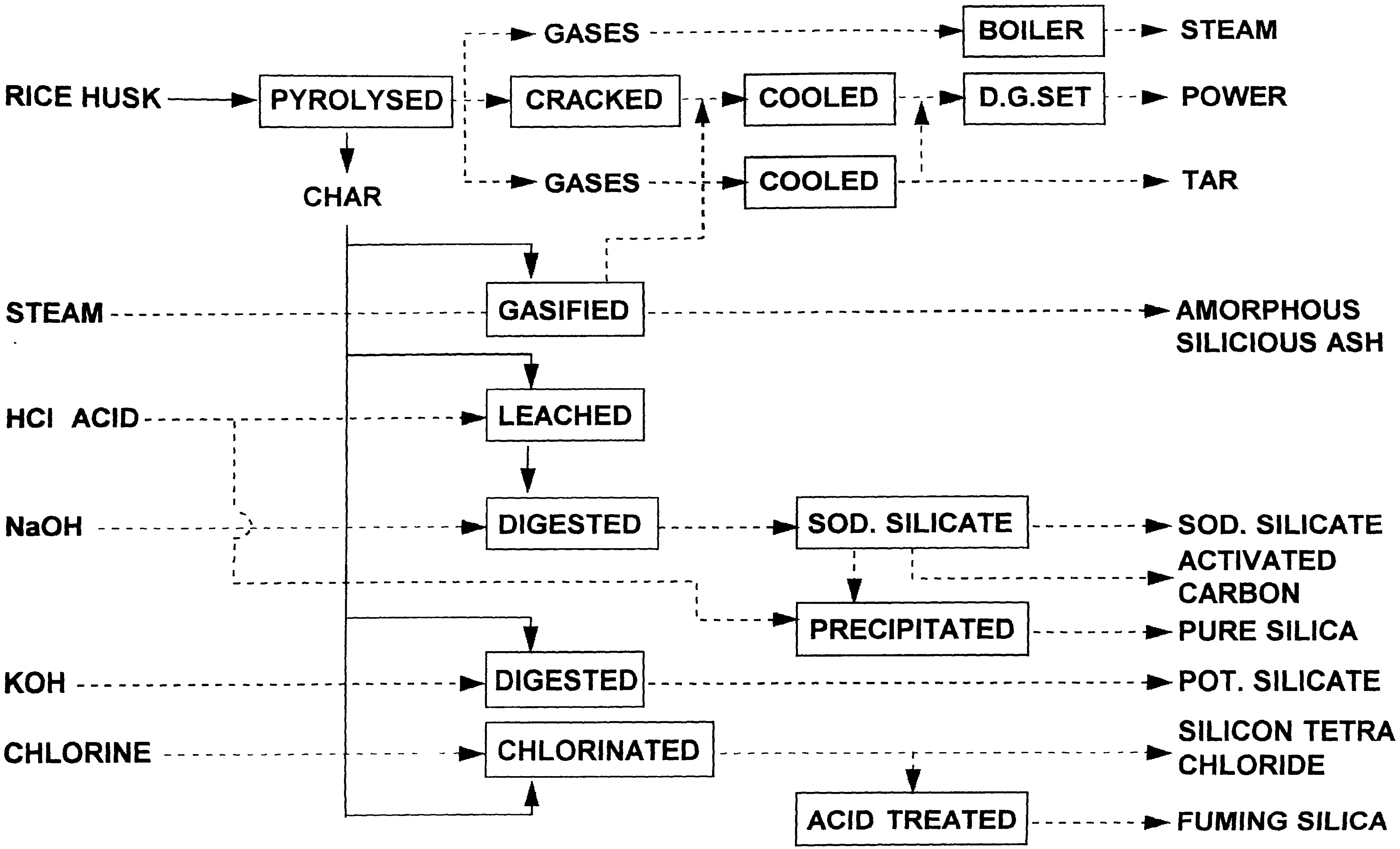


FIGURE - 3 ENERGY AND PRODUCTS FROM RICE HUSK rayon industries or sold as such as barbecue fuels Tar is separated from liquid products and processed into household germicide (popularly known as phenyl) and black paint Gases, without separation of tar can be used as fuel for boilers and after removal of tar, for generation of power Alternately, the tar laden gases can be cracked in a separate cracker cum gasifier (Figure 2) The char can also be converted into activated carbon

Under category IIB, the biomass species included are the same as in category IIA, except that these are available in wet form having 50% moisture content Additional residues are sugar cane milled bagasse, coir pith and others The technologies suggested are the same as in category IIA except that the pyrolyser should have an integrated drier The yield of products is also accordingly different

Under category III, the biomass species having higher ash contents (>4%) have been included These species are rice straw, soybean husk, sorghum bagasse and similar materials The materials may also have low ash melting points due to presence of p73 potash and other alkali metals in ash These are normally difficult materials even for combustion in boilers/furnaces and tend to produce more tar

These materials can best be utilised by low temperature (about 600 deg C) pyrolysis With or without recovery of tar, the gases can be combusted in boilers and the char (because of high ash content) can be used only as domestic fuel. The char is normally light and comparatively requires more compaction A pyrolyser configuration similar to those in category II can be employed

Category IV, accommodates only technologies based on rice husk(RH). Rice husk has been classified into a special category because of its unique properties and is considered as nature's best gift for recovery of energy and value added industrial products

Rice husk contains 65% volatiles, 15% fixed carbon and 20% ash Furthermore, the rice husk ash(RHA) contains more than 97% finely divided amorphous or reactive/biogenic silica which is an extremely useful industrial product But these favorable properties of silica are destroyed by burning RH in boilers

When RH is subjected to high temperature (>750 deg C), its silica content tends to become crystalline and part of this also combines with carbon and finally results as inert black ash This ash has no use and is even worse than river sand Disposal of this 30-40% RHA and RH combustion associated particulate emissions are the two main causes of extensive pollution Gasification systems based on direct injection of air also generate useless black ash Although gas obtained after gasification can be used for clean combustion, the pollution problems associated with RHA disposal are not solved. It is, therefore, pertinent that only those technologies be adopted which do incorporate the zero pollution concept and also produce value added products The products obtainable from rice husk are shown in Figure-3 [5]

5.0 BIOMASS FEED PREPARATION

Except wood, all other biomass species have very low bulk densities Accordingly, these are inconvenient and uneconomical to handle, store and transport Furthermore, direct use of these materials for energy are associated with inefficient conversion and widespread combustion related pollution. For their efficient and pollution free utilisation, it is imperative to process these materials so as to make them as convenient fuels

Feed preparation techniques mainly comprise of sizing, like making wood chips, densification and carbonisation

To carry out above operations, it is invariably desirable to dry the materials, either naturally in sun or through mechanical processing.

5.1 Drying

While green wood contains 50-55% moisture, various agro-residues have the same or higher moisture content. These are needed to be dried to extract maximum energy Table-5 gives the heating values of typical biomass on wet and dry basis

Table-5 HEATING VALUES AND MOISTURE CONTENT

Biomass Residues	H.H.V. (dry) (MJ/Kg)	Moisture Contenth (%)	H.H.V. (wet) MJ/Kg
Wheat straw	17.3	12-22	12 9-14 9
Rice straw	14 6	12-22	10 9-12 6
Bagasse	18 0	40-60	5 7-9 8
Coconut shells	19.1	10-20	14 9-17.0
Beet leaf	15 5	80-90	0 6-1 1

Firstly, biomass is dried in the sun upto 20-25% moisture and later by thermal processes Various systems are employed for drying Most common practice for chips and powdery materials is to simultaneously convey and dry there materials in entrained bed or flash pneumatic driers.

5.2 Size Reduction

Many biomass residues are cut in smaller sizes for easy handling and efficient combustions Straw and stalk type materials are chopped by chaff cutters into granular materials either for baling or for easy transportation Similarly, wood is cut into chips for their efficient use in boilers Size reduction is needed for their use either in fluidised or suspension burning appliances. Though size reduction is necessary for many operations, it is desirable to use the materials is the form these are available as each conversion operation needs energy and their handling results in loss of material

6.0 BRIQUETTING TECHNOLOGIES [4]

The proven high pressure technologies presently employed for briquetting of biomass are by piston or ram type press and the screw or extruder type machines (Figure-4). Both the machines give briquettes with a density of 1-1 2 gm/cc and are suitable as industrial solid fuels Screw type machine provides briquettes with a concentric hole which gives better combustibility and is a preferred fuel These briquettes can also be more conveniently deployed in small furnaces and even cookstoves than solid briquettes generated by ram press.

The most common shapes of briquettes are either circular or hexagonal or octagonal in cross section, of 55-75 mm equivalent diameter and can be cut into any desired length The shapes of conventional briquette are shown in Figure 6

In addition, to these mechanical presses, hydraulic mode operated machines are also developed which can provide briquettes in any form including rectangular shapes of various sizes. But these are not very popular for biomass briquetting

6.1 Ram (Piston) press

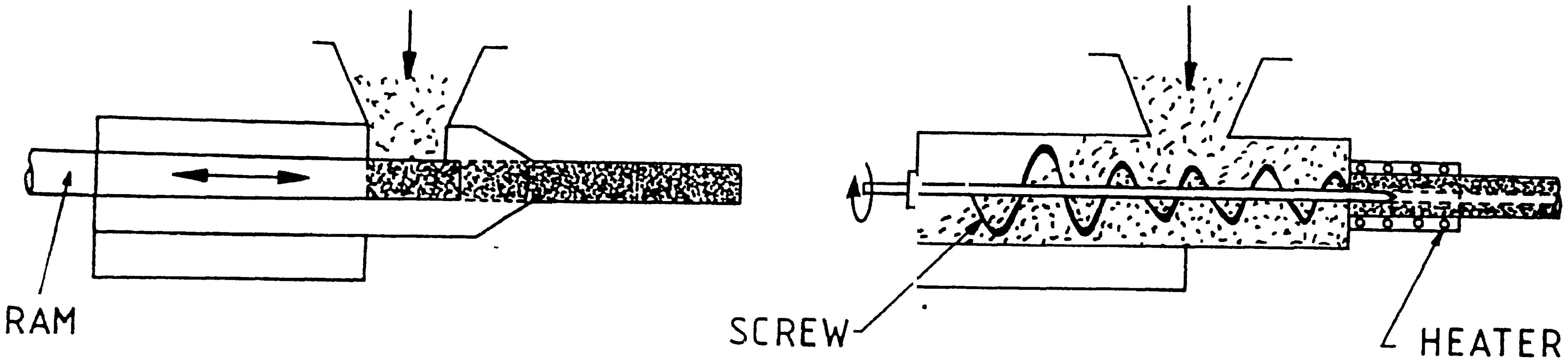
These machines operate in a discontinuous mode with material being fed into a cylinder which is then compressed by a piston (ram) into a slightly tapering die The material get heated due to friction forces due to the forced movement of compressed briquette At high pressure (1000 bars) and temperature around 250°C, the lignin content of biomass get hydrolysed and acts as natural binder.Accordingly, for high pressure briquetting, no external binder is needed Due to discontinuous nature of feed compression,the resulting briquette comprises of numerous discs pressed together forming a continuous log Many a times this transverse joints are weak and briquettes readily breaks into non uniform lengths

Because of reciprocating movement, these presses are driven mechanically by means of massive flywheels via a crankshaft or sometimes operated hydraulically. Output capacities which are directly related to the diameter of the briquettes range from 0 25 to 1 t/hr from single die machines Machines with multiple piston-die assemblies are also available.

The machines are robust and function reliably provided they have been installed properly with dies shaped correctly for the specific raw material Machines are perfected for sawdust and wood waste but may give mismatch between the feeding rate mechanism and taper sizes of the die for other agro residues (because of different bulk densities), which can lead to many operational problems including the capacity derating of machines

Maintenance costs for well engineered plants is reasonable, limited to the replacement of die after a few hundred hours of operation However, most of the similar plants manuanufactured by companies in developing countries have faced numerous mechanical problems due to poor engineering specially, with regards to dimensional tolerances and use of appropriate materials This has resulted in phasing out of many manufacturers.

BACK GROUND



RAM PRESS
BEFORE 1945
EROUPE & U.S.A
"PREST-O-LOG"(US)
"GLOMERA" (SWISS)
"COMPRESS" (FRG)

EXTRUDER
1945
JAPAN
635 PLANTS (1969)
0.81 MTY
"SHIMADA"

Fig 5.0

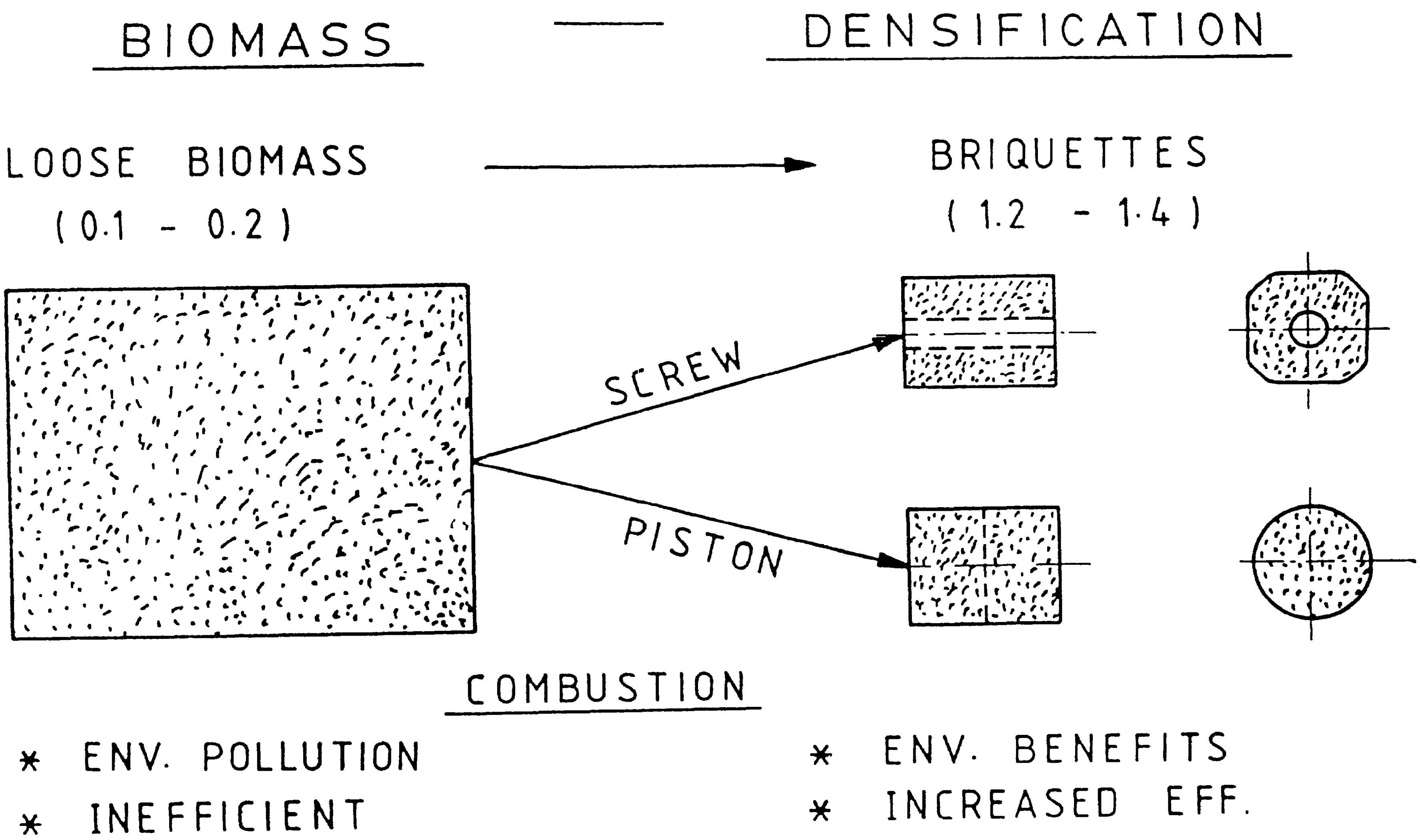

BIOMASS — DENSIFICATION
LOOSE BIOMASS
(0.1 - 0.2)
BRIQUETTES
(1.2 - 1.4)
SCREW
PISTON
COMBUSTION
* ENV. POLLUTION
* INEFFICIENT
* ENV. BENEFITS
* INCREASED EFF.

Fig 6.0

Specially in India, some manufacturers tried to modify the original European machines by increasing the briquette size so as to increase their output capacity and bring down the production cost without taking into the consideration the basics of material engineering and the process engineering involved in briquetting technology, resulting in their ultimate failures However, inspite of failures, the credit goes to the briquetting technology and its relevance in Indian context that more than 100 machines are working and many more are being installed.

6.2 Screw press

An earliest model known as PRES-TO-LOG was developed in the USA in the 30's as a low pressure conical screw press. This was independently further developed into a high pressure machine with externally heated die in Japan during the world war II. Another significant feature of this machine was the incorporation of an extension of the screw shaft to act as guide and provide hollow briquettes. This innovation enhanced the utility of briquettes as domestic fuel Further these could be carbonised into high density charcoal fuel which was then the widespread and preferred domestic and industrial fuel in Japan. The model became very successful and the design has been taken up by other manufacturers in Asia and also in Europe. Now well engineered screw presses are preferred by users to ram presses

In this design, material is fed continuously into a screw box which is then forced into a heated die made of heat and abrasive resistant material The machine runs smoothly and produces more homogeneous and denser briquettes of high quality than those from ram press.

The die temperature is maintained between 250-300°C which is close to the decomposition temperatures of most biomass species resulting in slight carbonisation of outer surface of briquettes. This imparts hydrophobic properties to the surface endowing the briquettes with longer shelf life

These machines are made by numerous manufacturers in many countries in Asia in capacities ranging from 60 to 250 Kg/hr European and Japanese models have higher capacities upto 600 Kg/hr.

Unlike in the ram machines, the feed material in screw press is simultaneously mixed, sometimes ground and then forced extruded accompanied by the emittance of volatiles due to surface carbonisation of briquettes These operations demand additional load and impose severe working conditions on the contact parts of the machine which need to be built in special materials This aspect is invariably overlooked and not incorporated by many Asian manufacturers, either due to lack of technology or on cost considerations This lack of proper engineering has resulted in extensive screw wear and frequent maintenance of machines leading to numerous failures of these installations

Well engineered presses, especially from Japan and Europe, are operating well for a number of years on briquetting of sawdust However, when these machines were tried on agro-residues, extensive wear of contact parts, in particular the front two flights of screw, were encountered leading to virtual failure of screw machines. Another disadvantage noticed was the extra specific power consumption, a major component of production cost

In the case of briquetting agro-residues, a substantial part of total power (about 50%) is consumed in feed preparation and p73 material handling system The conventional feed

preparation system involves· crushing of feed to 8 mm size (not required for coir pith or sawdust) and drying to 8-12 percent moisture

With a view to re-establish the confidence of the entrepreneurs amongst the developing nations of South East Asia in this eco- friendly technology, a large scale project was initiated by the Dutch Government and contracted to The University of Twente and Indian Institute of Technology, Delhi The extensive tests, carried out in Delhi on 400 kg/hr Shimada machine, resulted in solving these problems of excessive wear of screw and higher power consumption By preheating the dry and crushed agro- residues to 90°C and application of a controlled tungsten carbide hard facing on screws, consistently improved performance of the machine was obtained

While working on most abrasive biomass, rice husk, life of screw was increased from 15-20 minutes to 33 hours with 25% increase in production rate 15 5 tonnes of briquettes were produced before the screw was taken out for hardfacing.

Reduction in specific power consumption was noticed from 70 to 55 kWh/t for rice husk and 30 kWh/t for coffee husk Production rate for coffee husk was obtained as 600 kg/hr from rated output of 400 kg/hr, an increase of 50% The cost of screw maintenance which was prohibitive without preheating was brought down to Rs 30 per tonne from Rs.150 per tonne

The latest development of preheating the feed has given productivity and maintenance results on agro-residues comparable to those being obtained in Europe on sawdust and technology has now become economical for its adaptation.

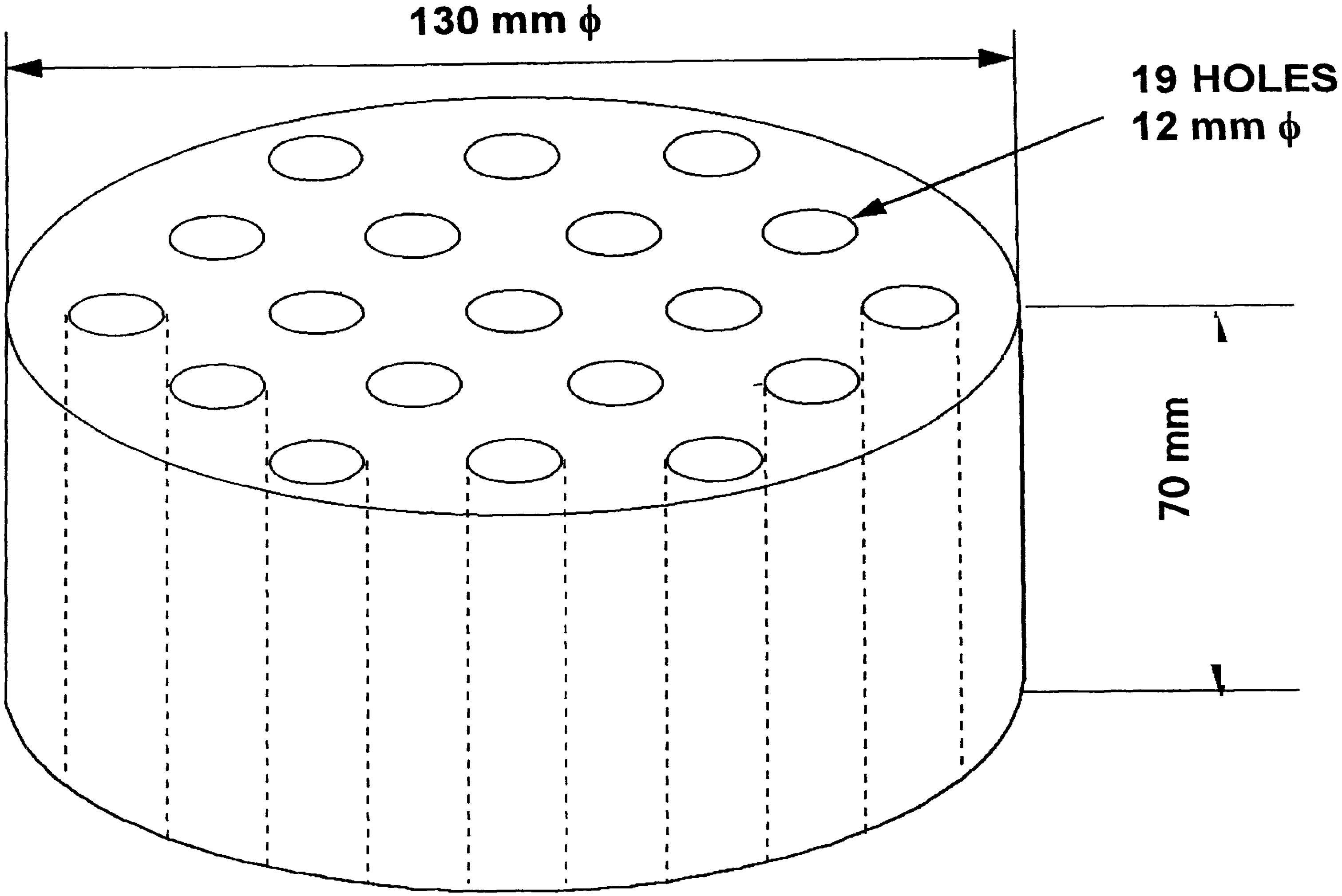
6.3 Pellet presses

These presses operate by extruding small diameter pellets (10-30 mm) by pressing eccentric rollers inside a large perforated cylindrical or conical die Originally developed for pelletising fodder or mineral ores,they have found limited applications in making biomass pellets These have high capacity of 5-20t/h and are highly capital intensive which are the main deterrent for their application for biomass

6.4 Low pressure screw presses

Low pressure machines normally involve a pressure of 5 MPa(50 bars), intermediate pressure machines work in the range of 5-100 MPa and high pressure presses generate

CHAR BEEHIVE - BRIQUETTE



COIR PITH

GAS AND CHAR SYSTEM

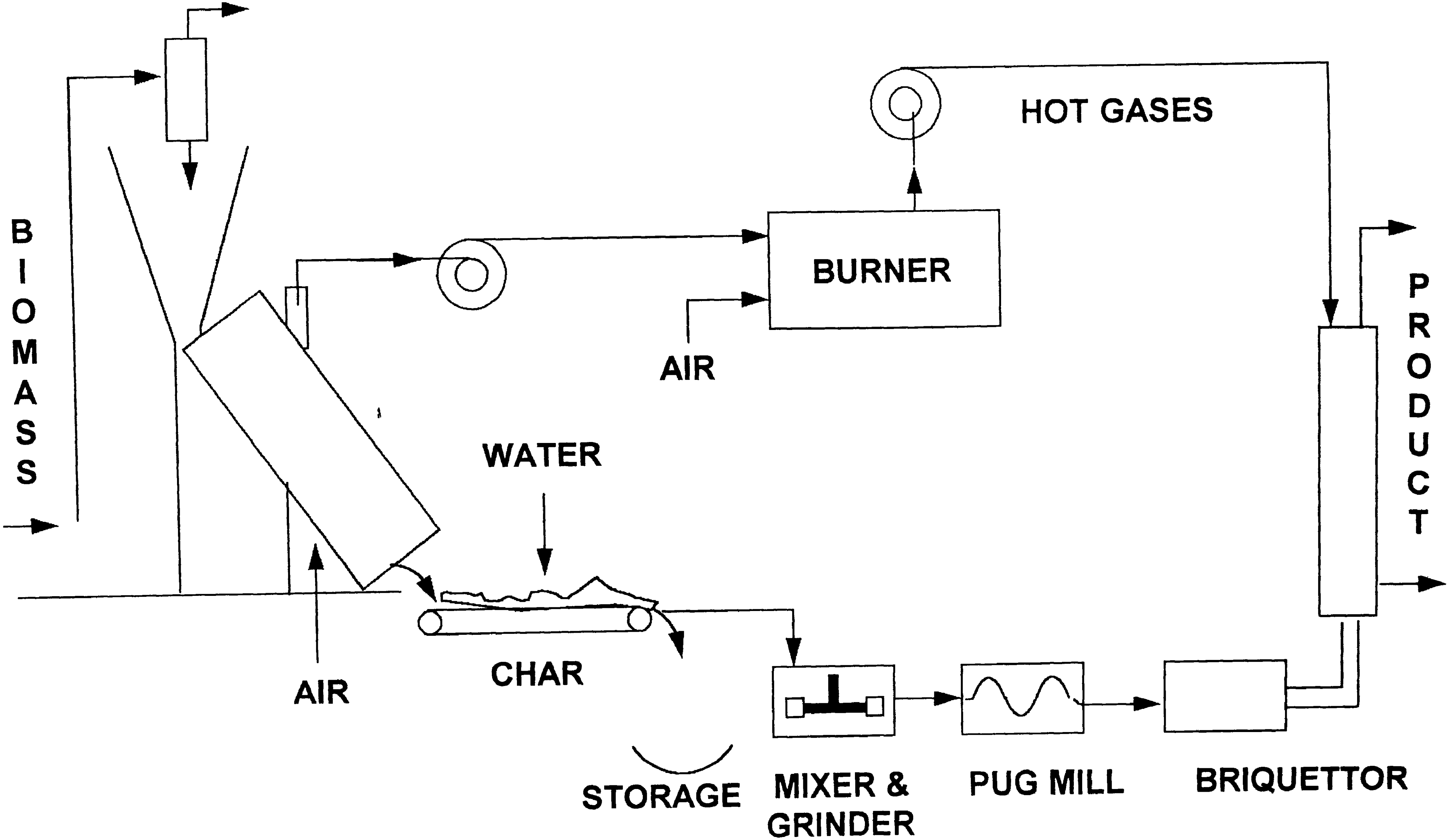

BIOMASS
HOT GASES
BURNER
AIR
PRODUCT
WATER
AIR
CHAR
STORAGE
MIXER & GRINDER
PUG MILL
BRIQUETTOR

Fig 8.0

pressure higher than 100 MPa Depending upon the pressure applied, the bulk densities of original material can be increased by 2-10 times by briquetting techniques Normally, low pressure briquetting needs binder, it is optional for medium pressure machine and not required for high pressure units

The main advantage of low pressure screw press is that the p73 material with 30 to 50 percent moisture can be compacted Binder like bentonitic clays, lime molasses and starch can be used for these machines, the power consumption is low For example, a screw extruder being manufactured by Sai Kampangsaen Motors, Thailand has a capacity of 500 kg/hr and powered by 5 kW motor driving a screw at 800 rpm The cost of machine was US$ 1000 (1993 prices) The cost of screw was $100 and it needed repairs after 65 tonnes of production. Briquettes produced are normally soft (density = 0 3 - 0.5) and must be placed by hand on trays used for air drying [9] These machines have limited applications, but in right circumstances, may be a low cost route to briquetting

7.0 CARBONISATION and BRIQUETTING

Partial pyrolysis followed by briquetting of char using binders is the most suitable and economical route for utilising most material including coir pith The objective of pyrolysis is to just destroy the fiber and retain most of the energy in the char By controlling carbonisation parameters, it is possible to retain about 60 percent of original energy in char The char is then mixed with binders such as bentonite, lime, molasses and non edible starch (powder tamrind seeds) and briquetted or pelletised in any desired shape and size and then dried in sun or in a dryer In case of continuous or semibatch mode of carbonisation, hot gases from the kiln can be burned and flue gases used to dry the green briquettes On small scale, briquetting can be done manually Bee-hive briquettes (Figure-7) with 30-35% potter's clay are recommended for domestic use Depending upon location, carbonisation can be done in perforated oil drums, troughs, brick/even mud kilns of larger capacities or continuous kiln of any configuration Inclined grate carboniser as shown in Figure is recommended A layout of carbonised briquetting plant, indicating the type of machinery required is given in Figure-8

8.0 BROAD ECONOMICS [4]

The installed and operating costs of briquetting and carbonisation plants are highly site specific and also depend upon the type of technology employed and its capacity The degree of mechanisation incorporated in the plant which differ from plant to plant of the same type and capacity, also influences these cost factors Further, whether the machine is purchased from the industrialised countries or locally made do have different price structure and quality of machines Poorly engineered machines will have more maintenance costs It is therefore recommended that a pre-feasibility report should be got prepared for each proposed installation before venturing into briquetting/carbonisation of biomass

Some preliminary cost data is provided to indicate the order of investment and conversion costs based on conditions presently prevailing in India The costs are given in U.S. dollars with conversion rate of 1 US$ equal to 33 3 Indian rupees

(1) Screw press briquetting

Capacity = 1 T/hr with 2 machines imported from Japan/Europe
Yield (Based on 10% moisture in feed) = 80% of feed
Cost of machine = $ 85,000

Cost of plant (fully mechanised with drier and hammer mill) = $ 180,000

Cost of production (with 80% capacity utilisation 300 days in year) = $ 16.6/tonne

(2) Screw press briquetting (small capacity)

Capacity = 100 kg/hr one machine from India
Yield(Based on 10%4 moisture in feed) = 90% of feed
Cost of machine = $ 7,500
Cost of plant = $ 10,000
Cost of production = $ 16.0/tonne

(3) Piston press

Capacity = 1t/hr with two machines from India
Yield (Based on 10% moisture in feed) = 90% of feed
Cost of machines = $ 60,000
Cost of plant (with drier and hammer mill) = $ 120,000

Cost of productionh = $ 16 5-18.0

(with 60% capacity utilisation)

(4) Drum carbonisation and manual briquetting)

Capacity = 200 kg/2 days operation
Investment = 120
(4 drums and two moulds)
Yields = 30%
Cost of production = 6.4/100 kg
(Refer to sec 9.0 for further details)

(5) Brick kiln carbonisation and semi mechanised briquetting

Capacity = 1 ton/day
Cost of plant (includes two kilns & briquettor & drier) = $ 20,000
Yield (based on 10% moisture) = $ 35-40 percent of feed
Direct cost of Production = $ 30-35/tonne

(6) Mechanised carbonisation and briquetting plant

Capacity = 5 tonnes/day
Cost of plant & machinery (Includes kiln and briquettor and drier) = $ 1,00,000
Yield (10% moisture) = $ 30-40 percent on feed
Cost of Production = $ 18-20/tonne

Low Density Briquetting Plant

Capcitym(50% moisture) = 500 kg/hr - 8 hrs operation
Cost of machine = 1000
Cost of plant = 4000
Poduction cost = 16/tonne

9 0 DRUM CHARRING AND BRIQUETTING

This is a potential technology which can be propagated as an income generating activity The major inputs required are only manpower and availability of any type of agro-residues or even MSW or both This technology can produce smokeless fuel for domestic sector and the enterprise can be started as a tiny unit in a decentralised mode The techno-economic details of a model enterprise based on conditions prevailing in a typical developing country like Myanmar are presented.

9 1 Model enterprise

BASIS · Four charring drums

(a) Material balance and expected production

Char ar Char = 20kg per drum per batch and two batches per day
= 160 Kg
Clay Required (20 percent of char) = 32 Kg
Residual moisture in dry briquettes = 10 Kg

BRIQUETTE PRODUCTION PER DAY = 202 Kg

No of briquettes (each weighighing 400 grams) = 500

RAW MATERIALS REQUIRED
(Avg. 30 percent yield)
= 540 Kg

(b) Manpower

Labour (Full time) 2 persons
Labour (Part time) 2 persons (as and when required)

(c) Cost data US$

Cost of 4 drums ($20 each drum) = 80
Cost of 2 sets of mould ($10 each mould) = 20
Miscellaneous hand tools etc. = 20
Total = 120

(d) Sales (Based on prices in Myanmar)

Saleable at $0 06 per briquette (6 x 500) = 30
Less 20% Commission and transport charges = 6
Net sales = 24

(e) Operating expenses (8 batches in two days including briquetting)

Labour ($1 per person per day)		= 6.0
Labour (For collection and transportation raw material at rate of $0.01 per Kg)		= 5 4
Miscellaneoush		= 1 5
Total		= 12 9
	say	= 13 0

(f) Gross profit = 24 - 13 = 11 in two days.

Taking 10 such operations per month, this venture can generate an income of more than US $ 100 after payment of wages at the enhanced rate of $1 per day per person In case, the labour is provided by the family members, the income can be as high as US$ 224 per month Since such ventures are site specific, the project economics should be analysed for each situation.

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Biomethnation – an overview

by

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BIOMETHANATION - AN OVERVIEW

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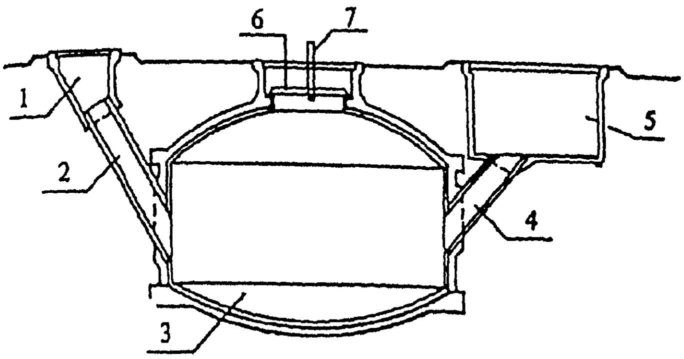
The fermentative process of conversion of organic matter to a mixture of methane and carbon di-oxide gases, commonly known as 'biogas', was traditionally applied for treatment of waste with the aim to "stabillize" it. However, during the last over two decades, both the developed and the developing countries have evincing interest in biomethanation from the viewpoints of pollution control, energy generation, enriched manure production and health improvement. Besides, various social benefits such as reduction in the drudgery of rural women, better sanitation, improved environment, ecological restoration, etc., accrued due to biogas production units have received added importance.

Small Scale Technology:

It is a point to note that in the developing countries particularly China and India, the biomethanation is being practised to stabilize pig and cattle manure respectively on a very large scale. Approximately, over 6 million and 2 million small sized biogas units have been functioning in China and India respectivel y. An analysis of their biogas promotion programmes reveals that these countries have not only developed and adopted simple-to-construct and easy-to-operate small sized biogas production designs (Figure 1) but also combined it with a sustained political framework and administrative preparedness coupled with financial and training support. Among other cuntries, Bangladesh and Nepal have suitably adopted the technology, but the harmonious efforts made in the recent past in Nepal, which has most difficult terrain and not much favourable climatic conditions, have paid dividends in terms of installing a total of over 25000 biogas units and presently adding 10,000 more units every year. In fact, Nepal has added a new feather in its cap by promoting private construction companies and farmers' participation. Thus, the Nepal's programme should encourage many other developing countries to overcome the shock of past failures and start making rapid progress now onwards.

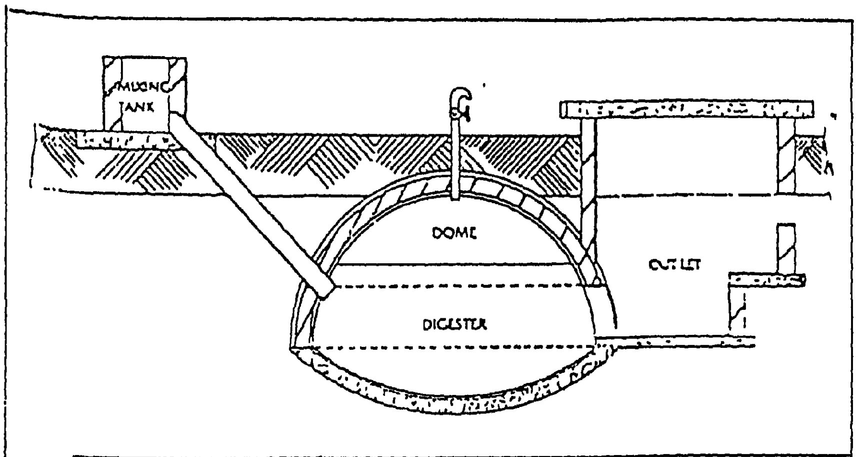
It would not be wrong to conclude that Asian countries are the leaders in applying small scale biogas technology for production of energy as well as enriched manure. When due care is taken in motivating and training of all stake holders, including women users and also in maximizing the economic returns, besides social benefits, by ensuring supply of quality gas appliances and proper use of manure for value added products, the biogas technology would blossom.

With the increase in the foodgrain production, the

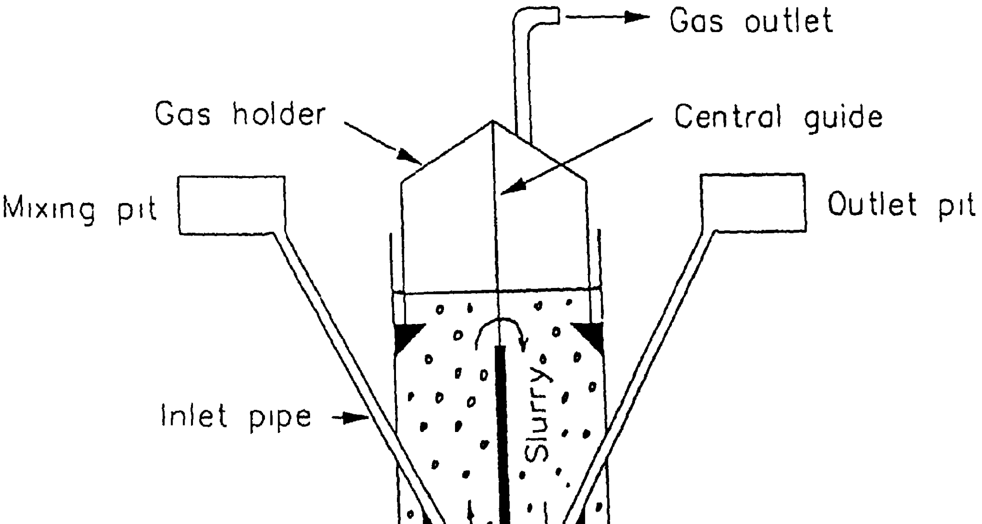


1. inlet opening
2. inlet pipe
3. fermentation compartment
4. outlet pipe
5. hydraulic compartment
6. removable cover
7. gas pipe

1.1 Fixed Dome (Chinese) Digester



1.2 Deenbandhu Model (Indian)



3 Floating drum Indian Model

Fig.1 Small Scale Biogas Digesters

stock of crop residues is expected to grow. While most of the residues would continue to be fed to animals, a sizeable quantity could be available for using as fuel material. In fact in China, paddy straw is already being used along with pig manure and human waste in biogas units. However, the rate of production of biogas from crop residues needs to be enhanced, possibly by micrbial manipulation, to improve the economic viability of the technology. In this direction, lignin and cellulose degrading bacteria have been selected and genetically improved at Tata Energy Research Institute (TERI), New Delhi with the support of Ministry of Non-Conventional Energy Sources (MNES). A consortia of such improved bacteria, when used with 50 per cent replacement of cattle dung by paddy straw in a small sized fixed dome biogas plant, have given encouraging results from the point of view of enhanced gas yield with minimum operational problem (Figure 2).

High Rate Reactors:

In the recent years with increasing environmental awareness, the Asian countries have also taken interest towards the high rate anaerobic reactors for production of biogas from agro-industrial effluents with the aim of recovering energy and remediating pollutants. In India, more than 60 alcohol distilleries have started using biomethanation process in combination of some other

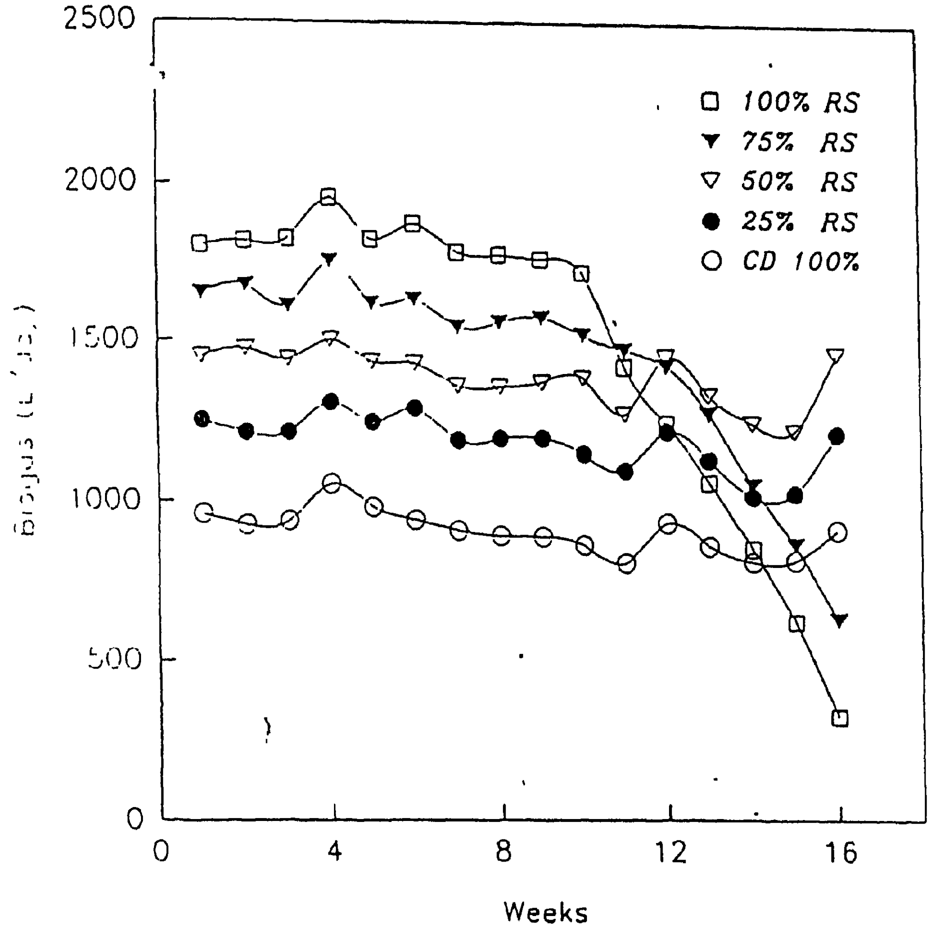


Figure 2. Biogas production from rice straw in 1 m^3 Deen bandhu model plant at various substitutions. When improved bacterial consortia used. (Courtesy: TERI, New Delhi).

secondary treatment to reduce the biological oxygen demand (BOD) and chemical oxygen demand (COD) to an acceptable level. Indian Renewable Energy Development Agency (IREDA), which is the financing arm of MNES, has been providing loans since 1987-88. In view of its economic viability, the recent Asian Development Bank's Appraisal Mission has recommended a loan of U.S. dollars 20 million to IREDA exclusively for disbursement on biomethanation projects.

While most of these industries have gone for some foreign technology (Table 1), the indigenously developed technology, particularly at the Daurala Sugar Works in district Meerut, Uttar Pradesh, with the R&D collaboration and support of MNES, has given equal, if not better, results (Table 2). A flow diagram of the diphasic biomethanation process in use at Daurala Sugar Works is given at figure 3.

Sewage Treatment with Energy Recovery:

Ministry of Environment and Forests have been supporting sewage treatment projects, with energy recovery wherever feasible, with a view to control pollution of rivers. In all, 5 projects based on USAB process have been in use at Allahbad, Kanpur, Mirzapur, and Varanasi and 4 more such projects are under implementation.

Table 1: Technical collaborations with foreign companies under IREDA funded biomethanation projects.

Technology	(Country)	No. of projects
SGN	(France)	5
Degrement	(France)	9
Biotim, MV	(Belgium)	7
ADI-BVF	(Canada)	3
Sulzer Bros	(Swis)	8
Paques BV	(The Netherlands)	4
Bacardi	(USA)	7
Dorr Oliver	(USA)	2
Lurgi, GmbH	(Germany)	2
Aqua Technos	(Thailand)	3
Indigenous	(India)	7
	Total:	57

Table 2: Performance highlights of the biomethanation plant capacity of 1600-1650 m^3 effluent/day in use at Daurala Sugar Works, U.P., India.

Parameters		Performance
BOD	:	83-85% reduction
COD	:	67-70% reduction
COD loading	:	9-11 $kg/m^3/day$
Total retention period (acid+methane phase)	:	11-12 days
Gas production rate	:	32-35 m^3/m^3 of effluent
Biogas composition		
- Methane	:	60-65% v/v
- H_2S	:	Less than 0.5% v/v

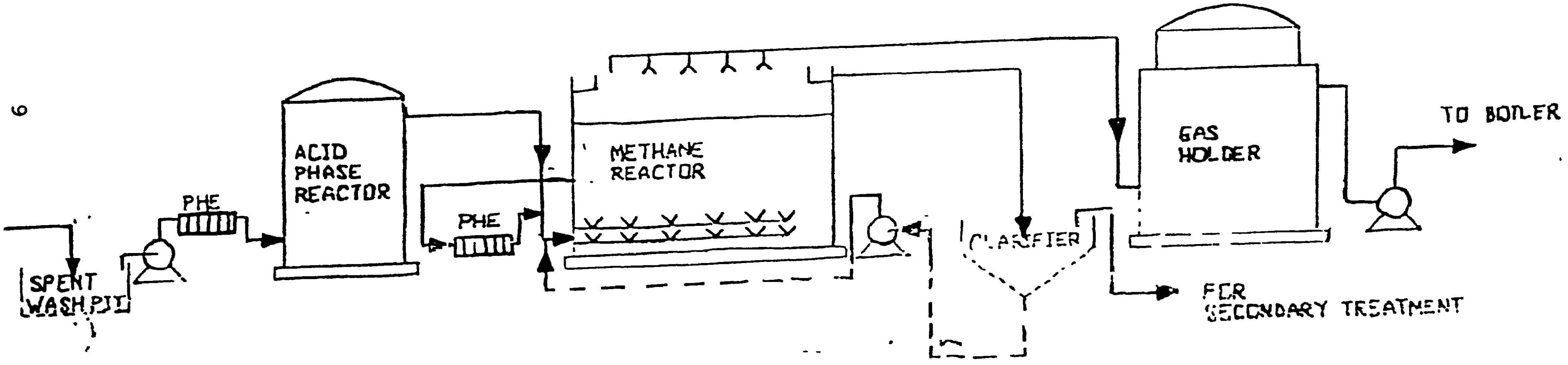


FIG. 3. FLOW DIAGRAM OF DIPHASIC BIOMETHANATION PROCESS AT DAURALA SUGAR WORKS, U P. INDIA.

Municipal and other Solid Waste Treatment:

A GEF-assisted project entitled "Development of high rate biomethanation process as a means of reducing greenhouse gas emission" is being implemented mainly to take up pilot demonstration projects based on municipal solid waste, slaugther hosue waste, vegetable market waste, etc. Some of the State Governments have taken initiatives in announcing conducive policy package to provide garbage at free-of-cost and land at nominal lease fee on a long-term basis and also power purchase agreement at a remunerative price. These efforts are expected to attract private sector participation and foreign investment.

Conclusions:

The developing countries like China, India and Nepal have widely applied small scale biomethanation technology for production of energy to meet cooking, heating and lighting fuel requirements as well as supplement chemical fertilizers, besides harnessisng several social benefits. However, the benefits at the national level in terms of saving of forests, improving soil productivity, reducing soil erosion, improving sanitation, addressing gender issues, etc., do not make the technology financially viabile to individual households to attract private investment. Therefore, national governments' initiatives are essential even to promote these simple and locally built low-cost units.

In case of high rate biomethanation reactors, while their economic viability has been well established in Europe and the United State of America, the developing countries would require not only foreign technology but also foreign investment. Simultaneously, more research and development has to be carried out to fine tune the designs to suit local conditions and to reduce the capital costs without compromising with environmental standards. Further promotion of biomethanation technology in the treatment of sewage, municipal solid waste and other organic wastes is required to be integrated with the national as well as global environmental policies.

Acknowledgements:

The author duly acknowledges sources of information, namely, MNES, Government of India; IREDA, New Delhi; TERI, New Delhi and Daurala Sugar Works, Meerut, Uttar Pradesh.

Recent Progress in Bioresidue Gasification Technologies

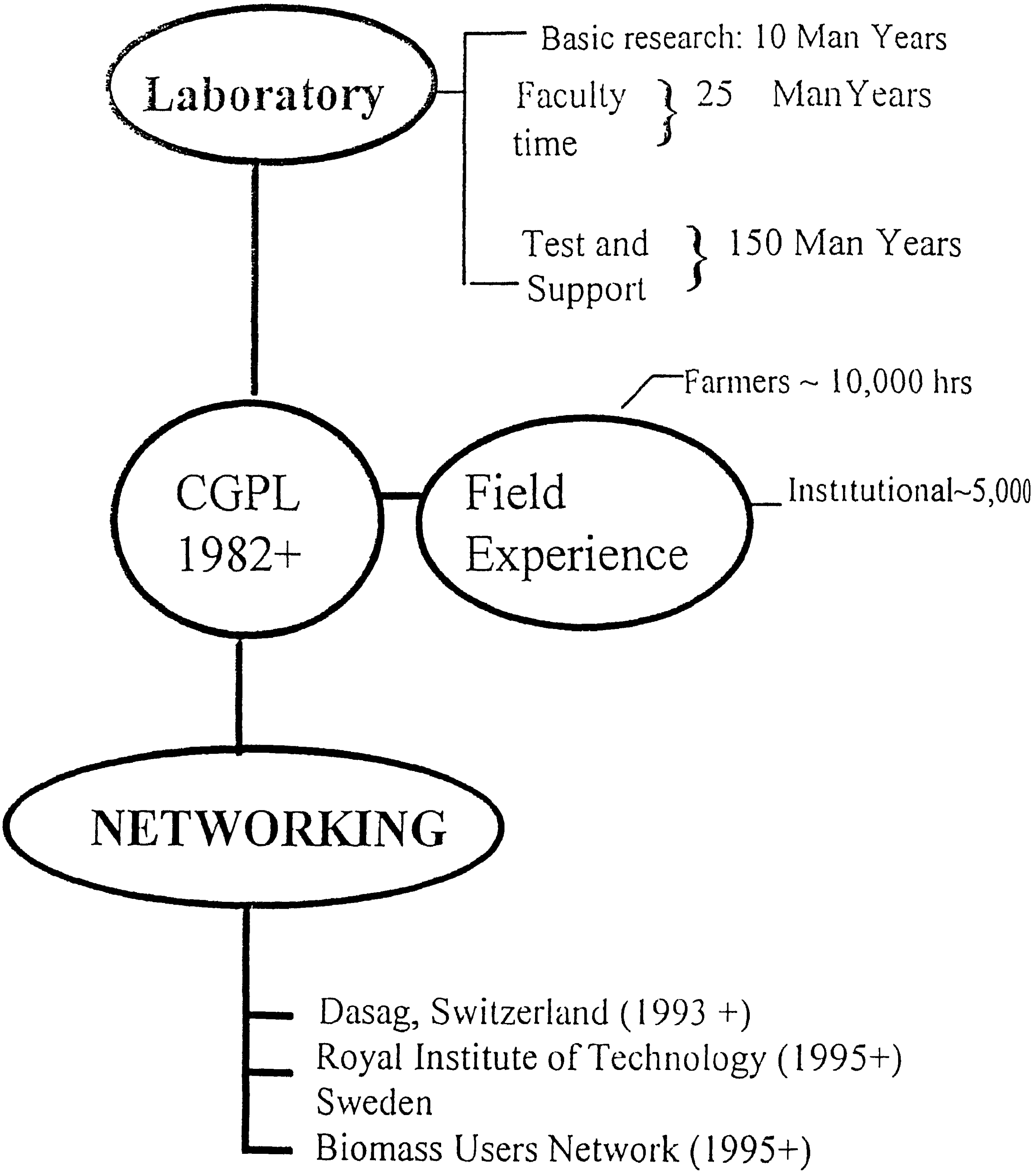
by

Prof. H S Mukunda
Indian Institute of Science, Bangalore

RECENT PROGRESS IN BIORESIDUE GASIFICATION TECHNOLOGIES

Combustion, Gasification and Propulsion Laboratory,
Department of Aerospace Engineering;
Mechanical Engineering;
ASTRA,
Indian Institute of Science,
Bangalore 560 012, India

- Introduction
- Woody Biomass Technology
- Pulverised Fuel Technology
- Concluding Remarks



Laboratory

Basic research: 10 Man Years

Faculty time } 25 ManYears

Test and Support } 150 Man Years

CGPL 1982+

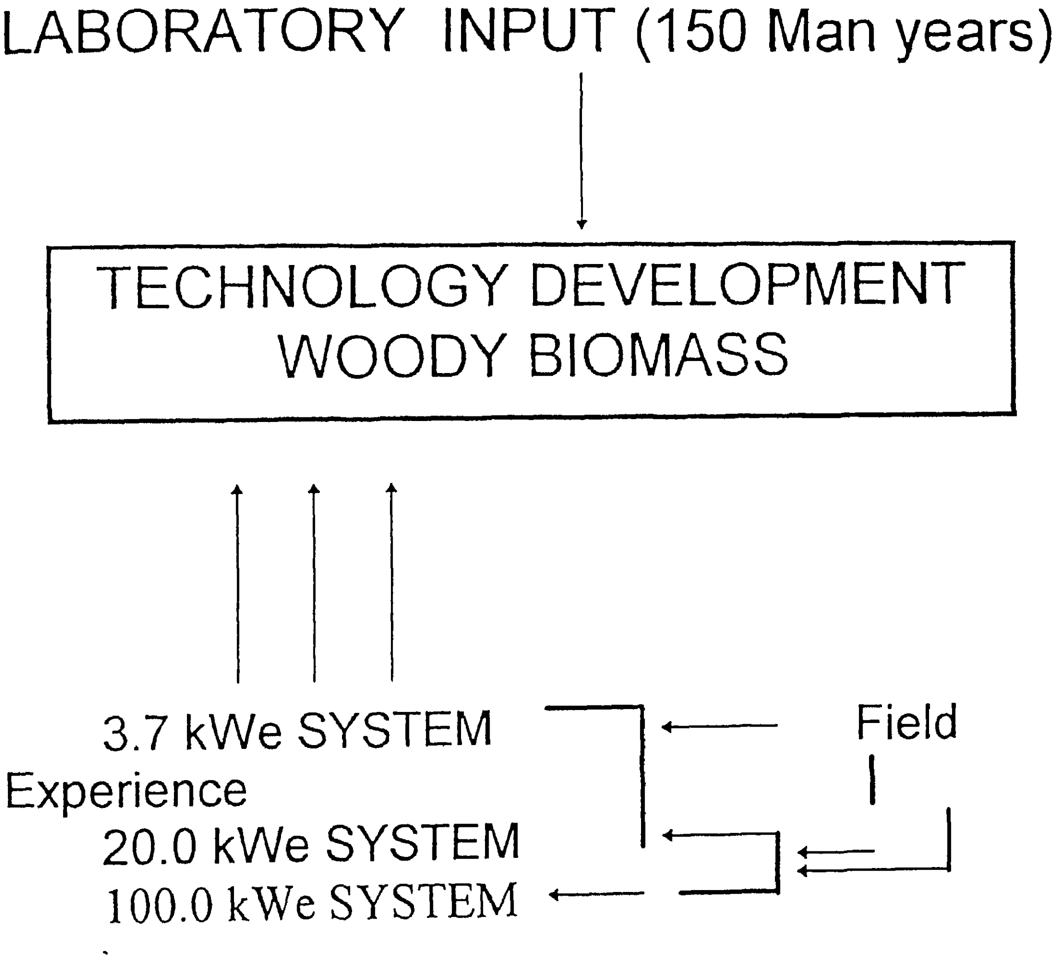
Field Experience

Farmers ~ 10,000 hrs

Institutional~5,000

NETWORKING

- Dasag, Switzerland (1993 +)
- Royal Institute of Technology (1995+) Sweden
- Biomass Users Network (1995+)



LABORATORY INPUT (150 Man years)

TECHNOLOGY DEVELOPMENT
WOODY BIOMASS

3.7 kWe SYSTEM

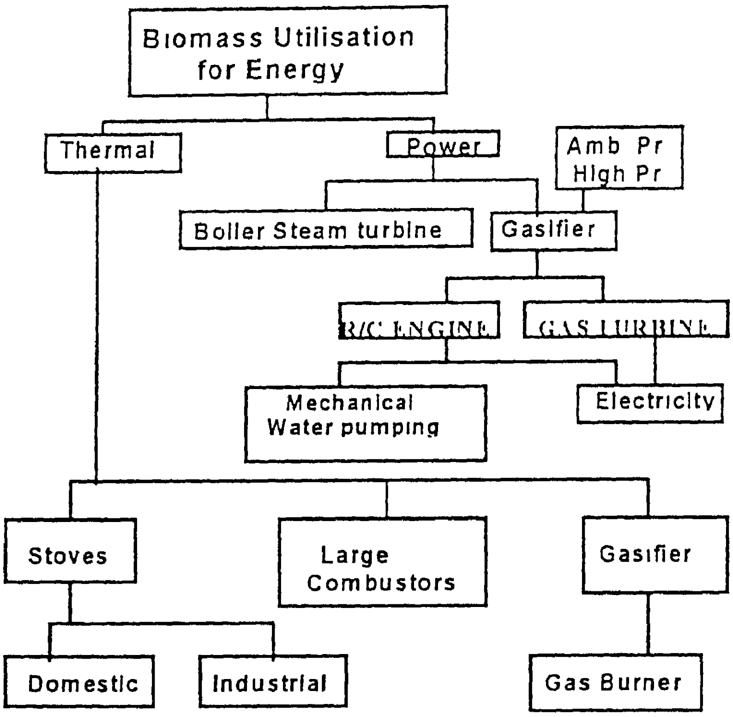
Experience

20.0 kWe SYSTEM

100.0 kWe SYSTEM

Field

Biomass Utilisation Strategy



Applications

Thermal (Diesel/Electricity Replacement)

- Drying⇒50 to 150 °C(with/without clean up)
- Hot water/cooking ⇒100 to 500 °C
- Non ferrous melting ⇒ ~ 1200 °C
- Ceramic industry ⇒ ~ 1350 °C

Mechanical/Electrical Power

- Water pumping 2 0, 3 7 kW, upto 100 kW
- Rural electrification 3 7 to 100 kWe
  Industrial electricity servicing upto 5 Mwe

Bio-resource classification

WOODY	PULVERISABLE
* Branches of wood	Rice husk, Rice straw
* Some agricultural wastes	Saw dust
Cotton sticks and	Sugarcane trash
Mulberry sticks	Bagasse
Lantana Camara, Prosopis Julifora	Coir pith, Peanut shells
Density > 250 - 300 kg/m^3	< 250 - 300 kg/m^3
Ash < 2 %	~ 6 - 20 %

Bulk Densities of Common Pulverised Fuels

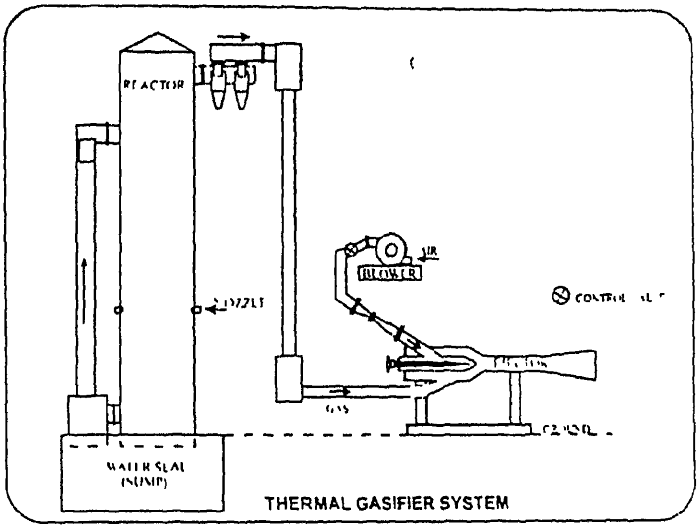
Fuel (sun dry)	Ash (%)	Bulk Density (kg/m^3)
Saw dust (< 3 mm)	< 10	300 - 350
Rice husk	20	100 - 130
Rice husk pulverised (< 2 mm)	20	380 - 400
Sugar cane trash (chaff cut)	6	50 - 60
Sugar cane trash (pulverised, < 4 mm)	6	70 - 90
Ground nut shell	3 5	120 -140
Ground nut shell (pulverised, < 2 mm)	3 5	330 - 360

FLAME TEMPERATURES

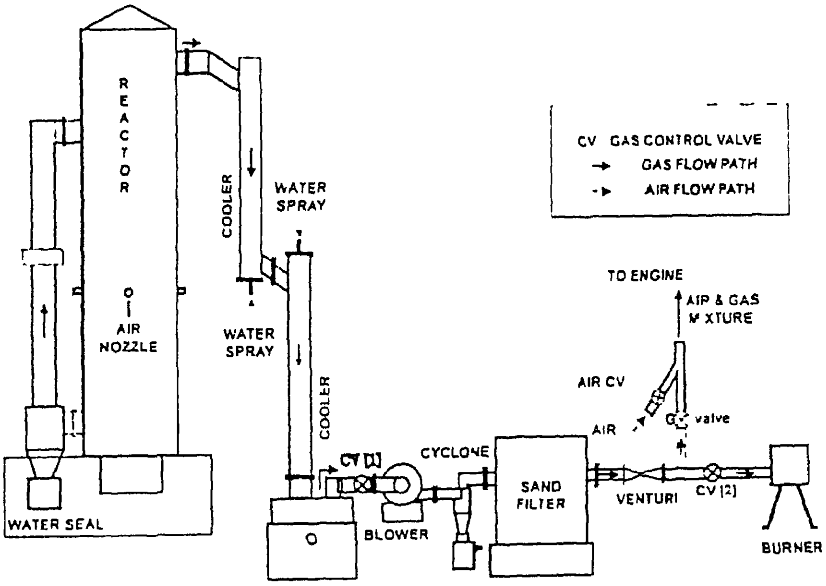
Fuel	Energy MJ/kg	Max. Flame Temperature, K
Petroleum fuel	40 - 44	1800 - 1900
Wood	14 - 17	1300 - 1700
Rice husk, other shells with high ash	10 - 13	1000 - 1300

If the fuel is pulverised, air-to-fuel ratio properly maintained, and heat losses are minimised, one can get a flame temperature as high as 1400°C, typical temperatures quoted for large liquid fuel burner operations

Item	Direct Combustion	Gasification
A/F Control (Instantaneous)	Inadequate (Fuel size, shape, moisture variation)	Good char reduction process permits auto-control
Power control (Instantaneous)	Inadequate	Good
Emission control (NO_X, SO_X, Dioxisms)	Possible	Superior
Installed Cost/kW	-	Higher on retrofit, comparable otherwise
Electricity	Economical only at large power levels (~ a few MWs)	Economical even at smaller power levels



THERMAL GASIFIER SYSTEM



SCHEMATIC OF WOOD GASIFIER FOR POWER GENERATION

Materials for the Systems

Reactor:

Hot zone Cermaic + Outer MS + Insulation
Top zone Double shell SS
Recirculating Ceramic lined SS tubing Duct

Cooler: SS tubing

Plumbing: PVC

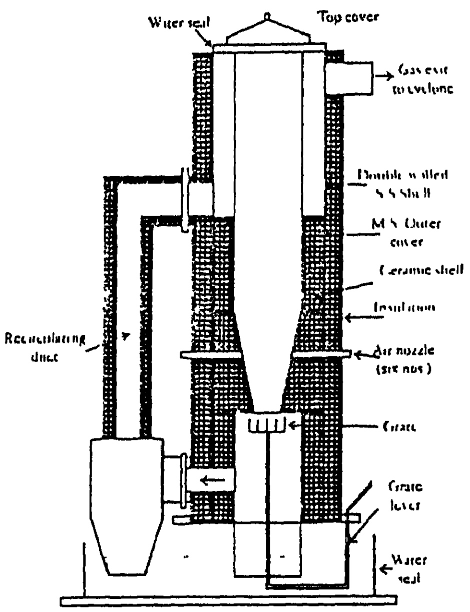


Fig 1. SCHEMATIC OF REACTOR

Woody residues tested

Species	Density (kg/m^3)	Moisture content (%)	No Hours	Chip Size for 100 kWe
Causarina	550 to 650	< 15	200	~ 75 mm, Mixture with tiny branches 50 %, 10 to 15 mm, + 10 % Sawdust
Eucalyptus + mixed species	400 to 650	< 15	6000	50 to 75 mm
Phadauk	1050 to 1100	~ 15	700	Same as above
Silver Oak	250 to 300	~ 20	150	Same as above
Pine (European)	200 to 250	< 30	30	Same as above
Mulberry stalk	300 to 350	~ 15	1000	10 to 20 mm dia, 30 to 50 mm long (20 kWe reactor)
Eipomia	200 to 250	~ 15	8	On small reactor
Jungle wood	300 to 600	~ 20	100	- same as above -
Arecanut husk	100	~10	30	- same as above

Results

Diesel replacement in every case tested on a variety of diesel engines exceeds 85 % at 80 % rated load.

Detailed results available on causarina.

Paramater	Value	Comments
Gasification efficiency (Hot)	80 % to 85 %	At full load, about 5% reduction at 30 % load
Gas Cal Value	4 5 to 4 8 MJ/m^3	Cal value equilibrates after 1 to 3 hours from start.
Hydrogen Content	16 to 19 %	Hydrogen fraction behaviour same as above, better fraction in wood with 10 to 15 % moisture. Important for engine application
Particulate (Hot) (Cold)	700 mg/m^3 50 mg/m^3	Hot tar is an indication of the load on the cleanup system
Tar (Hot) (Cold)	120 mg/m^3 20 mg/m^3	
Particulate Size Distribution	0 7 to 2 microns	Gas could be consistent with gas turbines as well

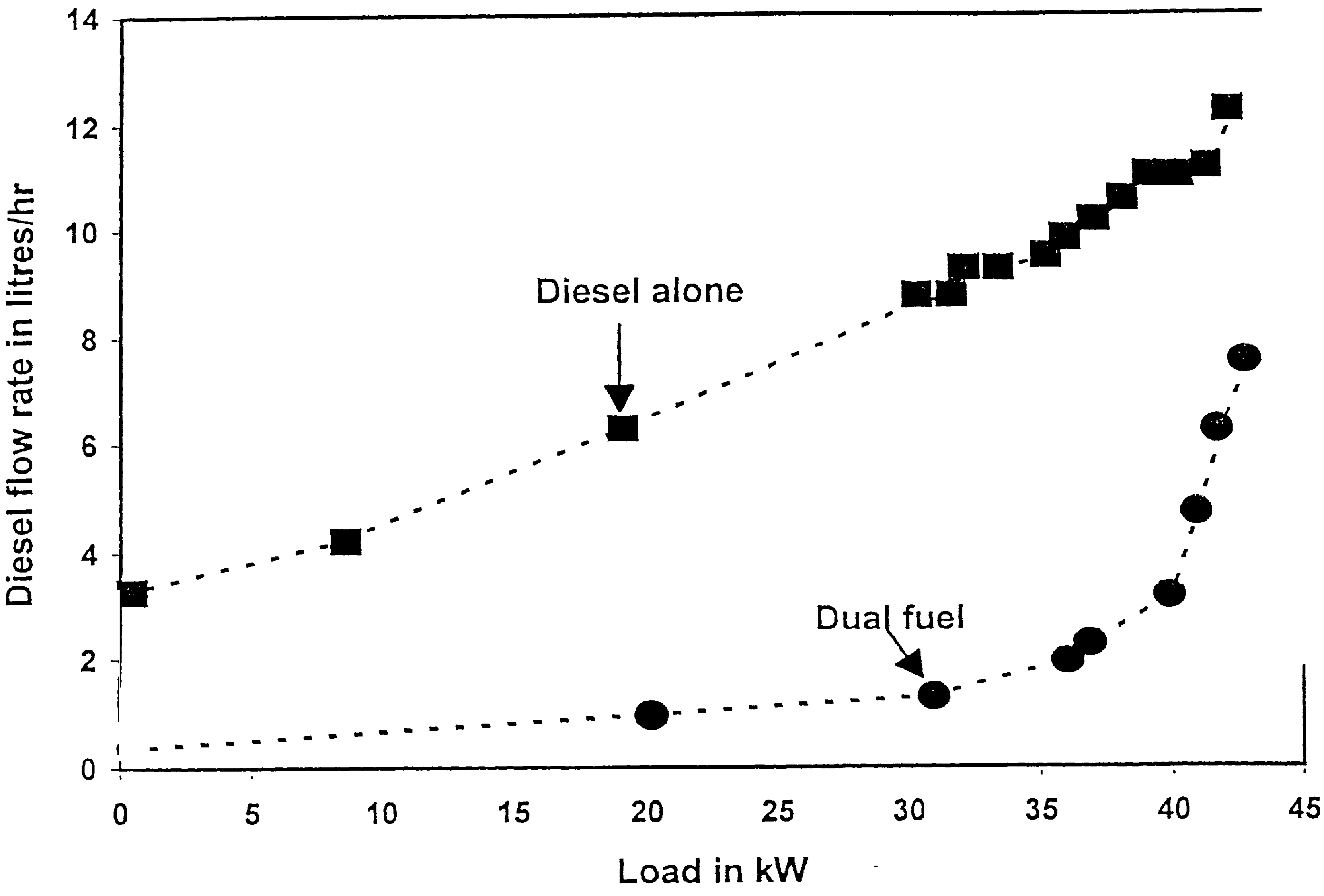
Additional Tests at Chatel-st-Denis (Jan-Feb 1996)

Swiss test team	Hot/cold
IISc test team	Cold/Hot (Both Total 11 tests)

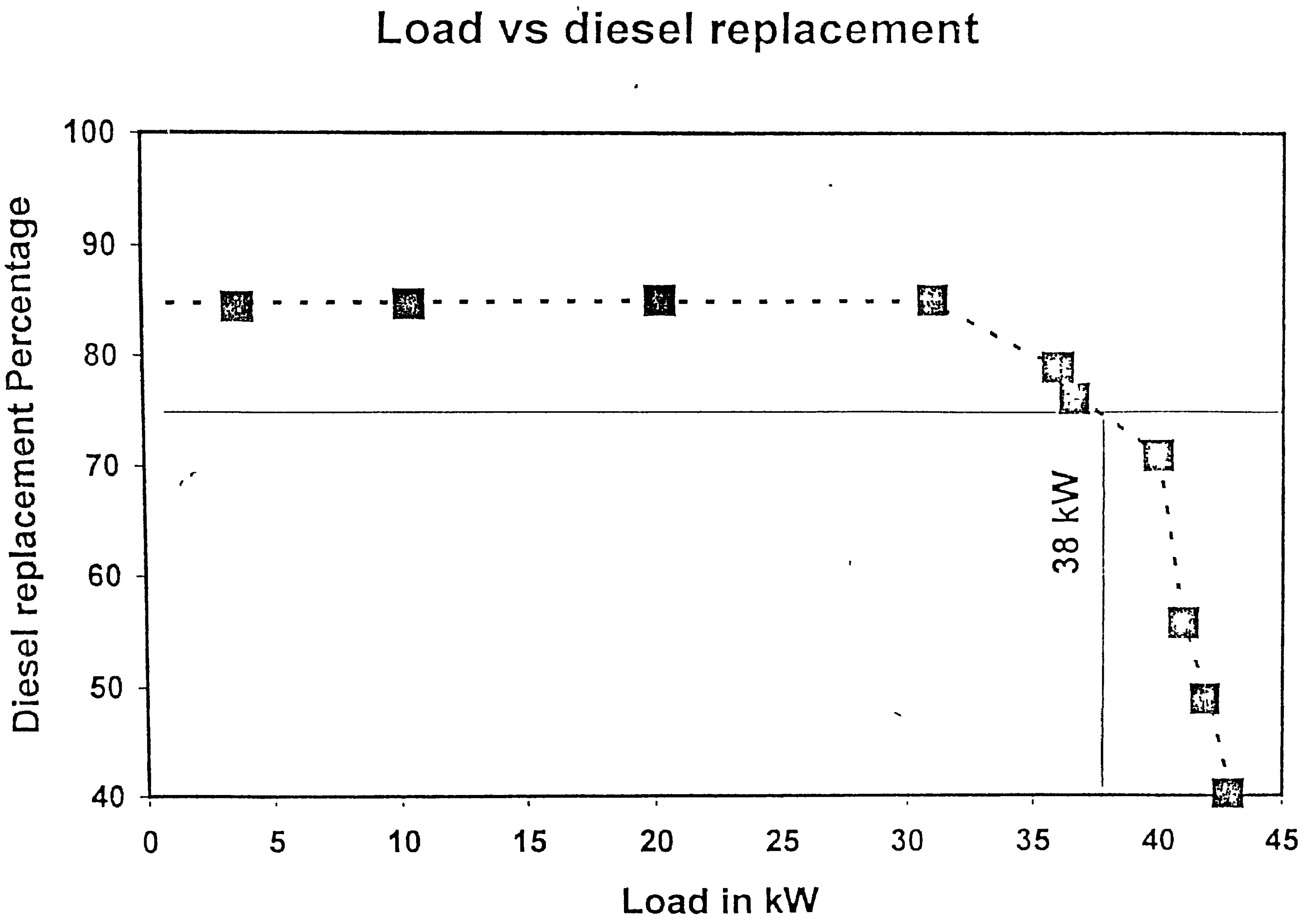
30-55-100% Loads

Results similar/better than at IISc

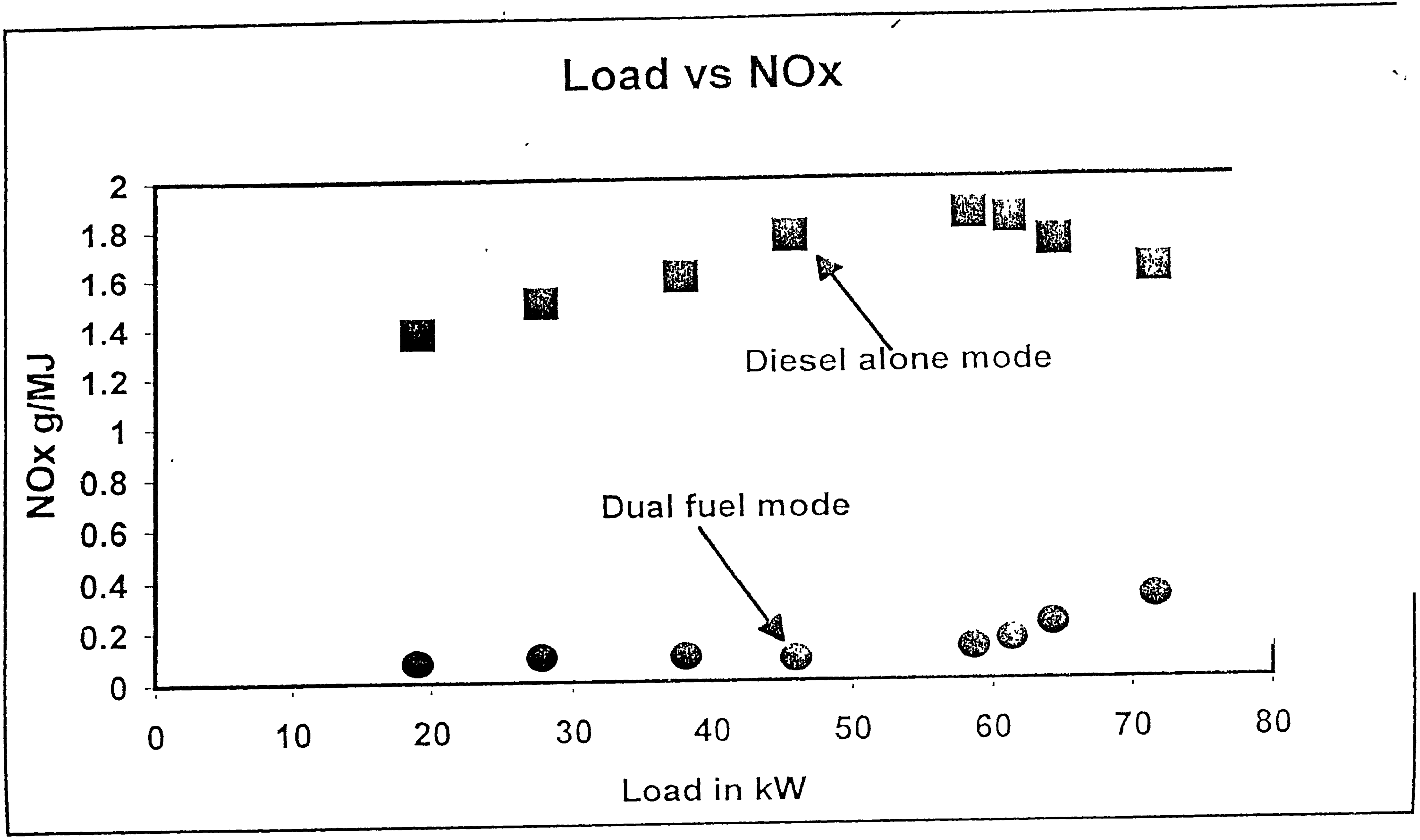
The system performed well under trying environmental conditions - Ambient of -5 to +10° C



Short duration engine test results on a 62.5 kVA Kirloskar RB 66 engine genset.
Diesel flow rate vs Load kWe



Short duration engine Test results on a 62.5 kVA Kirloskar RB 66 engine genset.
Diesel replacement vs Load kWe


Load vs NOx
NOx g/MJ
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Diesel alone mode
Dual fuel mode
0
10
20
30
40
50
60
70
80
Load in kW

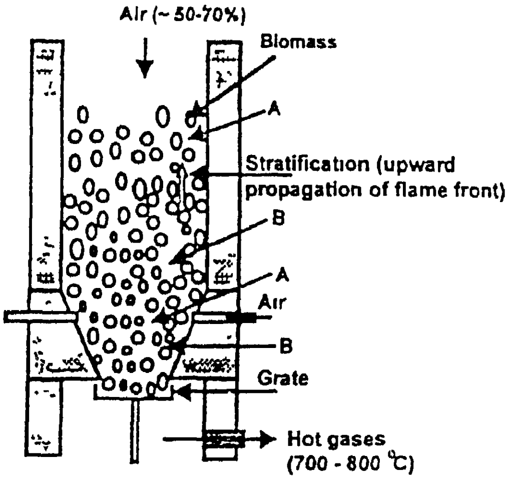
Pulverized Fuel Gasifier

- Extend the use of woody biomass gasifier
- Fluidised bed gasifier and Circulating fluidised bed system
- Cyclone gasifier

Why not woody biomass gasifier for pulverized fuels ?

Saw Dust Δp is high/ flow not uniform

$\Rightarrow$ tunnelling

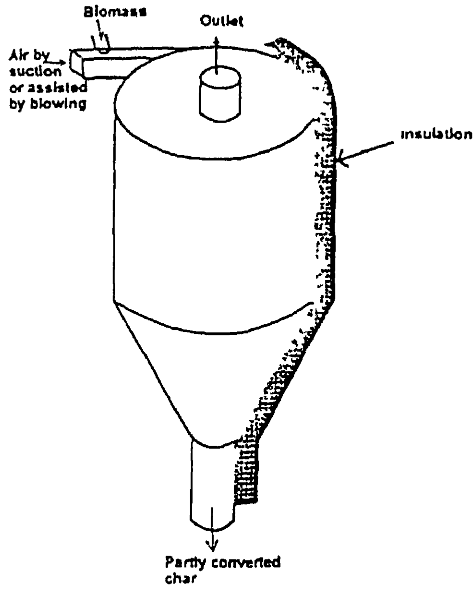


Rice Husk

Conversion of rice husk char is far too slow compared to flaming $\Rightarrow$ rice char fills up the space, the reactor acts virtually as a pyroliser $\Rightarrow$ tar in the gas is very high $\Rightarrow$ 10,000 - 20,000 ppm

- Volume reduction of rice char too small
  $\Rightarrow$ char removal system must be active continuously
- Chinese systems are based on the above principle
- Char conversion ~ 0, residue is quenched with water and discharged
  Too high a use of water
- Thermodynamically inefficient $\Rightarrow$ 2 - 2.3 kg/kWhr

Cyclone Reactor

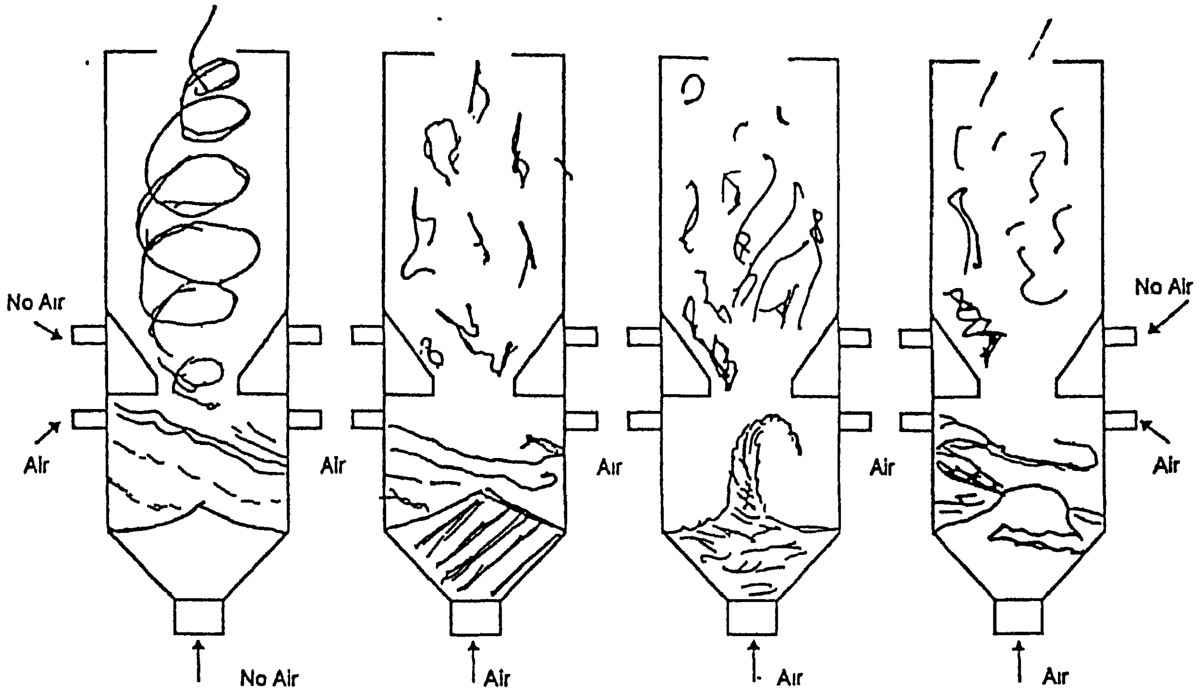


- Access of Particles to gas phase = Good

→ At reasonable velocities ⇒ Better Mass and Heat Transfer

Hot wall ⇒ Instant ignition

Figure 15 - Flow patterns observed in Spouted Bed cold model.

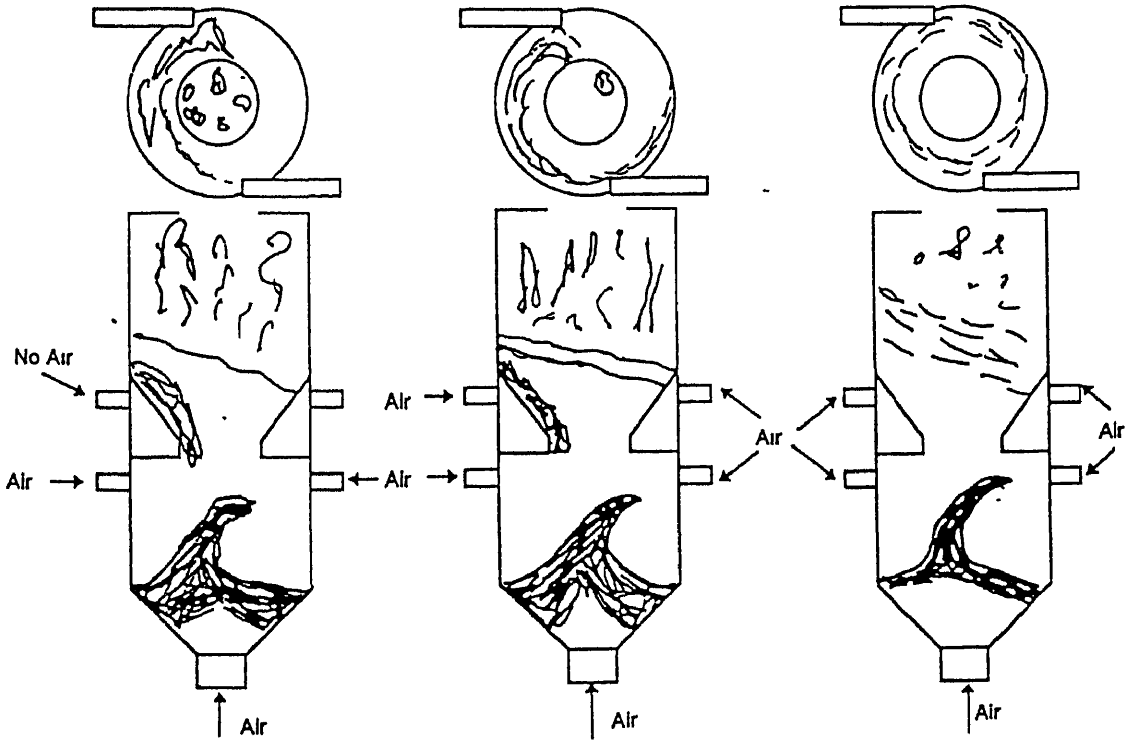


Condition 1

Condition 2

Condition 3a

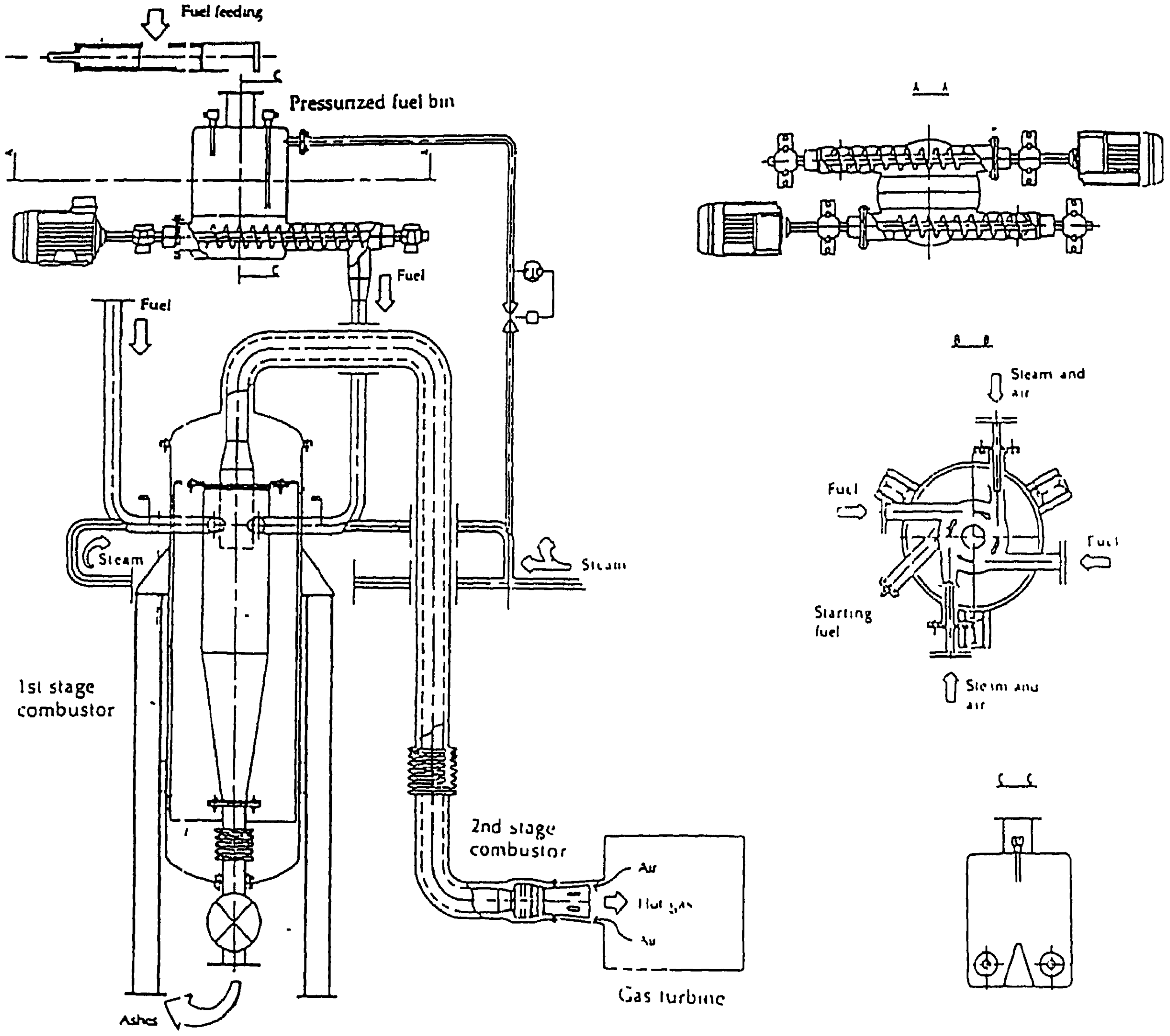
Condition 3b



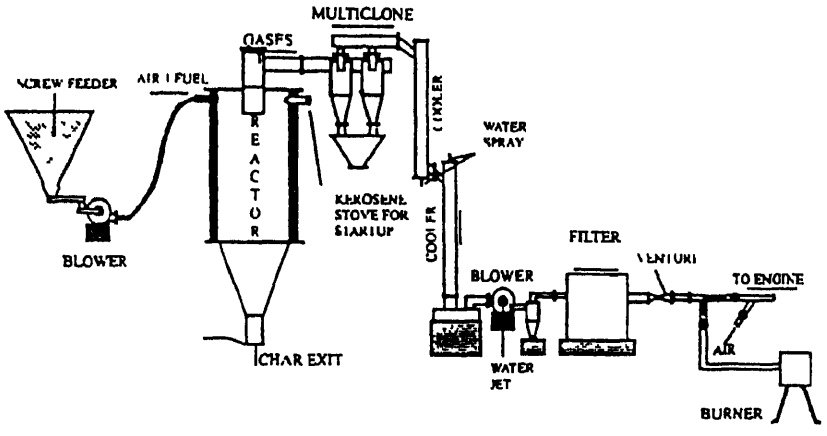
Condition 4a

Condition 4b

Condition 4c



Combustor and turbine arrangement for the bench-scale facility



POWDERY BIOMASS GASIFIER

Start - Up

Heat the inner walls to more than 600 K feed the pulverized fuel slowly increasing the rate till right A/F is obtained. Combustible gases are generated at this stage.

Method of heating :	Kerosene burner
Power of burner :	50 kWth (100kWe system) 500 kWth (2.7 Mwe system)
Starting time ·	30 min.

Char Removal System

Depends on an interesting Reactor Operational feature -

Pressure fluctuates inside the reactor beyond ambient for a small time but below ambient other times.
- On the average below ambient;

This causes material being pushed out
⇒ Occurs in the bottom where char collects;

With marginal help the material gets pushed out by itself
With rice husk whose char is dense, it works extremely well

CONTROL SYSTEM

Control requires for maintaining diesel replacement and mixture ratio in the gasifier.

- Mixture ratio
  - Gas quality depends largely on the gasifier mixture ratio.
  - Reactor wall temperature and exit gas temperature from the cyclone to be maintained within prescribed limits.
  - Too rich mixtures leads to high tar and low carbon conversion while too lean a mixture leads to low diesel replacement.
  - Feed rate to be adjusted based on measured gas flow rate reactor wall temperature.

Ash Handling

- Ash from rice husk gasifier contains mostly silica with some unconverted carbon and trace amounts other impurities
- Gasifier operation is conducted in such manner that the temperature of the ash does not exceed 650-700 °C, the phase transition temperature from amorphous to crystalline silica Hence the rice husk ash from the gasifier remains amorphous.
- Residual carbon is allowed to burn off by slow oxidation in air
- Process for further purification to produce value added precipitated silica under development.
- With the possibility of value addition, it is possible to cost the ash from this gasifier at Rs. 5-10 /kg.

Economics of Gasifier Operation

System Rating (kWe)	Gasifier System (million Rs)	Building space (mts)	Cost of Engine Genset (million Rs)	Cost/Unit (Rs.)
20	0.2	2 * 2 * 3	0.18	3.10
100	0.5	3 * 3 * 3.5	0.4	2.30

Concluding Remarks

- Validated and third party verified Woody Bioresidue Technologies are available
- Pulverised fuel gasifiers with quality of gas comparable to wood gasifier need some more development
- Those situations with facility for pumping water for irrigation say, can benefit from the current system
- Validation/third party verification of pulverised fuel gasifiers is to be completed.
- Techno economics of these systems are attractive as independent rural power producers.